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January-June, 1916

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The Canadian Engineer

A weekly paper for civil engineers and contractors

NEW OCEAN TERMINALS AT HALIFAX, N. S.

FIRST OF A SERIES OF ARTICLES DESCRIPTIVE OF ONE OF CANADA'S GREATEST ENGINEERING UNDERTAKINGS FOR THE IMPROVEMENT OF HER OCEAN COMMERCE—A $35,000,000 TERMINAL.

By LIEUT. T. W. J. LYNCH,
Formerly Assistant Engineer, City of Halifax.

At present Halifax is served by two terminals, one at Richmond, in the extreme northern section of the city and the other, the so-called "Deep Water Terminals," located more centrally, off Water Street, south of H.M. naval yard. A few years ago (1912) it was decided to construct large new ocean terminals, to be located considerably farther out in the harbor, at George's Island Bay, near the south or ocean end of the peninsula on which the city is located. The Minister of Railways and Canals for Canada accordingly instructed Mr. F. P. Gutelius, M.Can.Soc.C.E., now General Manager, Canadian Government Railways, and Mr. F. W. Cowie, M.Can.Soc.C.E., Chief Engineer, Montreal Harbor Commission, to prepare the comprehensive scheme which underlies the present constructional activities of which the following is descriptive.

Fig. 1.—Map of Halifax, Showing Location of the New Terminals.

The terminals, which have been designed to be the best equipped on the Atlantic coast, will consist of a bulkhead passenger landing quay, or wharf, 2,006 ft. long with 45 ft. depth of water at low water of spring tides, at which three of the largest ocean steamers can dock at the same time in safety and without tug assistance; a wharf building the whole length of the bulkhead quay, the first floor of which will be for freight and the second floor for passengers, customs and immigration quarters; also passenger and freight tracks that will run alongside the ships. The whole is laid out so as to give the most expeditious, convenient and economical arrangements for the transfer of passengers, baggage, mails and freight from steamer to rail and vice versâ.

Fig. 2.—Moving the Finished Block.

This scheme of development provides for the construction of five piers, 1,250 ft. long and from 320 to 360 ft. wide, equipped with wharf freight sheds and railway tracks; of railway yards for the storage and switching of cars; of elevators which will permit of grain being loaded into ships at each of 20 berths; of a central light, heat and power plant, and a locomotive house for switching engines; parlor, sleeping and dining car department and passenger coach yard, etc., and of a breakwater from Pt. Pleasant Park to the Reid Rock Buoy, about 1,600 ft. long in deep water.

The first unit will consist of the bulkhead quay with freight sheds and immigration buildings, passenger station and one pier equipped with sheds and tracks, together with all necessary accessories. This unit will provide accommodation for nine of the largest ocean steamships. As soon as business warrants it, more piers will be constructed, each giving an additional capacity for four such

steamships. In the near future, perhaps upon the opening of the Quebec bridge, provision will have to be made for further accommodation.

The union passenger station which will be built near the corner of Hollis and South Streets, will be a very handsome and substantial structure, provided with all modern conveniences and facilities for passengers and the

Fig. 3.—Making the Concrete Pier to Receive the Block at the Bottom of the Harbor.

handling of baggage, mails, express, etc. The passenger car yard will be situated immediately southeast of, and adjoining, the union station, and will be of ample capacity and equipped with all necessary heating supply buildings and up-to-date facilities.

The ocean terminals will be reached by a branch railway to be built from Rockingham, on the Intercolonial Railway, four miles from the North Street station at Halifax, about five miles from the present deep-water terminals and about six miles from the new terminals, which will be situated nearer the entrance to the harbor than any existing wharf. There will be no grade crossings, the railway being carried under the H. & S.W. Railway, and in all cases either under or over all streets and roads by means of bridges, the designs for which will be made to harmonize with their surroundings.

The railway has been designed for high-speed passenger and heavy freight trains. The maximum curvature will be 4 degrees and all curves will be laid out with suitable easements. The maximum gradient will be 0.6 per cent., compensated 0.04 per cent. per degree of curvature. To preserve the appearance of the residential section of Halifax along the northwest arm and in the vicinity of Pt. Pleasant Park, the railway will be constructed from Quinpool Road to Young Avenue in a cutting of sufficient depth to give clearance for the railway under the overhead bridges, which will carry the streets and roads over the railway. The line will be double tracked throughout, with additional lead tracks at the yards and terminals. The bridges, culverts and structures will all be of permanent construction. The excavations for the railway, which will greatly exceed the embankments, will consist mostly of rock. The surplus excavations from the northern end of the railway will fill in and reclaim from Bedford Basin a large and comparatively shallow area, which will be used for the new freight terminal yard. A suitable site for this yard would otherwise be very difficult to provide,

Fig. 4.—A Cutting Across the City.

on account of the very hilly nature of the peninsula and surrounding country. This new terminal yard will be open-ended and will have standing room for 1,000 cars on body tracks 4,000 ft. long, and it can be readily extended. It will take care of all freight to and from both the old and new terminals, transfer or switching engines

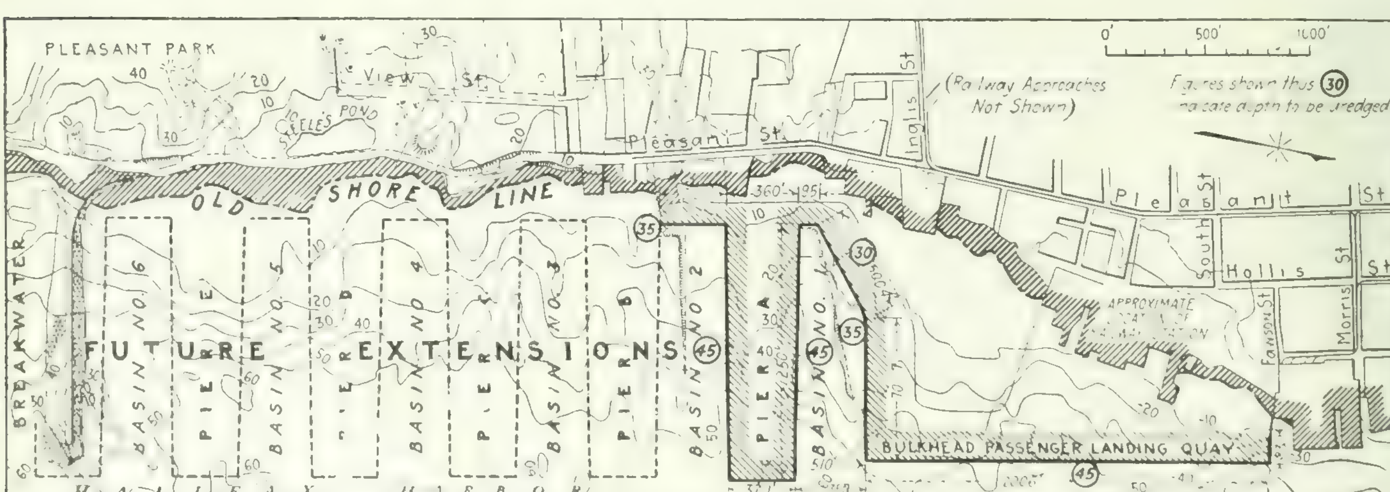


Fig. 5.—Layout of Quay and Piers and Location of Railway Terminal at Halifax. *(Drawing by courtesy Engineering News.)*

Fig. 6.—Filling the Forms with Concrete.

only being used between the new yard and the city and harbor terminals. The excess material from the railway cuttings at the southern end will be used for filling behind the quays and piers which are to be built in the harbor. Selected rock will also be obtained from the cuttings for the construction of the rubble mound breakwater, which will extend eastward into the harbor for about 1,600 ft.

The grading of the approach railway and the construction of the terminal yard at Bedford Basin and the breakwater at the harbor, the contracts for which were let to the Cook Construction Company, Limited, of Sudbury, Ont., and Andrew Wheaton, of Amherst, N.S., will be practically completed by the spring of 1916.

The estimated expenditures under the two contracts let are: (1) The Cook Construction Company, Limited, and Wheaton Brothers, for the grading of the railway and railway yards, including the breakwater, $1,750,000; (2) Foley Bros., Welch, Stewart and Fanquier, for quay walls, dredging, filling, shed foundations, sewers, etc., $5,500,000.

The whole scheme of terminals has been prepared under the direction and supervision of F. P. Gutelius, M.Can.Soc.C.E., General Manager, Canadian Government Railways; F. W. Cowie, M.Inst.C.E., Chief Engineer, Montreal Harbor Commission, is consulting engineer, and Jas. McGregor, A.M.Inst.C.E., to whom the writer is indebted for assistance in the preparation of this article, is superintending engineer in charge of the work at Halifax.

The deep-water terminals, now known as Pier 2,* have been completed as per contract and will be used for a year or two for passenger and freight purposes, until the ocean terminals are ready. The partitions and other interior fittings of the building will be removed and they will be used for freight purposes only.

Preliminary work was started at Fairview on the line of the new ocean terminals railway, July 31, 1913. The contractor's plant consists of five large steam shovels, electrically operated; fifty 12-yard air dump cars; four standard locomotives, and two Jordan air spreaders. The contract is being carried out jointly by a combination of the Cook Construction Company, Limited, Sudbury, Ont., and A. & W. D. Wheaton, Amherst, N.S.

On October 20th, 1915, Sir Robert Borden, Premier of the Dominion, and Hon. Frank Cochrane, Minister of Railways and Canals, assisted by other Dominion officials, visited the work and formally placed one of the 62½-ton concrete blocks in position in the quay wall. The ceremony was conducted amid immense dredges, scows, concrete mixers, cranes and other plant totalling in value over $1,000,000, which gave a distinct business tone to the event. A 100-ton crane gripped the block and swung it readily into place, while submarine blasting operations in the harbor added to the impressiveness of the agencies trained upon the work.

It is of interest to note that nine passenger steamships, as large as the "Alsatian," will be able to be alongside the quay walls when the present unit is completed and this space will be only one-third of the berthage room that will be provided when the whole undertaking is finished. A fleet of 27 ships, each as large as the "Alsatian," or any floating palace 600 ft. long, can then be accommodated at the piers at one and the same time. The northern portion of the unit, or passenger quay, will allow two "Mauretanias" to berth one ahead of the other. The ships thus provided for will have a depth of water alongside the piers of 45 ft. at low tide, New York having 40 ft. and Boston 35 ft. in the channel.

*For a description of the Halifax Deep Water Terminals see *The Canadian Engineer* for July 30th, 1914.

The reinforced concrete piles for the foundations of the depot and transit sheds, each from 40 to 60 ft. in length, will number 5,000. A force of 1,000 men, whose daily pay-roll is well over $2,000, with a similar expenditure per day for material, is an indication of the extent of present activities.

The quay walls running from the northern extremity of the passenger landing and around all the basins and piers will be 6,674 ft. in length. The area thus enclosed will be largely filled in by material taken from the railway cuttings by the contractors for that part of the undertaking, *i.e.*, the Cook Construction Company, Limited and Wheaton Bros. The quay wall is made up of concrete cellular blocks or shells, each weighing some 62½ tons

Fig. 7.—Making Reinforced Concrete Piles.

and faced from low-water mark up with granite. These shells are to be filled in with rubble and concrete, making a solid wall 31 ft. thick with a height of 60 ft., having a length of over 1¼ miles. The number of these concrete shells is 3,634, of which about 1,200 have been made and many are to be seen ready to be set in place. Their construction is illustrated in the accompanying views, and already about 350 have been placed in the quay walls, over 750 feet of which have been built.

The concrete in these shells will amount to 110,000 cubic yards and a similar amount of concrete will be required to fill them when placed. The total concrete in the walls will be approximately 260,000 cubic yards. Some 25,000,000 lbs. of steel reinforcing, 400,000 barrels of cement, and 300,000 cubic yards of gravel will be required. The cut granite facings for the quay walls will amount to 103,000 square feet. Extensive granite quarrying is being carried on for this undertaking in the Dominion Government quarries at Purcell's Cove at the mouth of the northwest arm.

An extensive freight tunnel system underlies practically every street in the downtown business district of Chicago, Ill., reducing surface vehicular traffic by one-third.

RECENT PROGRESS AND TENDENCIES IN MUNICIPAL WATER SUPPLY.

IMPORTANT work has been done during the past decade in the development of sources of water supply. Much interest attaches to recent large gravity supply developments of very remote surface sources. Two such projects of unprecedented magnitude and importance have been carried almost to completion within the past ten years, and a third has been developed to the point where construction will be possible in the near future. These projects receive especial mention in John W. Alvord's paper read at the International Engineering Congress, of which the following is an abstract.

The Catskill Supply.—The greatest single municipal water supply project so far undertaken is the Catskill supply for New York City. This project is designed to furnish 250,000,000 gallons per day as first completed, at a cost of about $200,000,000, and will be capable of enlargement to supply 500,000,000 gallons per day. The need for such a supply was foreseen as early as 1900, and led, after exhaustive investigations, to the beginning of construction in 1906. Impetus was given to the work by the drought and threatened water famine in 1911, and completion of the entire undertaking is now expected in about a year.

Los Angeles Aqueduct Supply.—The city of Los Angeles, in 1913, carried to virtual completion the largest single water supply project conceived and finished within the decade just past. This work, for boldness of conception and speed and economy of execution, is an excellent demonstration of the possibilities of municipal enterprise. When, in 1904, Los Angeles faced the prospect of outgrowing its municipally owned water supply of 40,000,000 gallons per day, the first definite steps were taken to secure an adequate supply for future needs. It was decided, after thorough investigation, to develop a gravity supply from Owens River, 250 miles distant, and construction of the great aqueduct began in 1907. This aqueduct, now completed, insures to the city 259,000,000 gallons per day of mountain water at a cost of $24,500,000, exclusive of power development. All water in excess of the city's present needs will be sold for irrigation and the great height of the source (3,812 feet) permits of several water power sites from which the city expects to derive additional revenue.

Hetch Hetchy Project.—The way has been paved during the past ten years to practically insure the construction in the near future of another great municipal water supply project, very similar to and rivalling in magnitude the Los Angeles aqueduct. This is the Hetch Hetchy project proposed for the future water supply of San Francisco and the adjourning bay cities. This project, as now planned, involves a gravity aqueduct 170 miles long, of 240,000,000 gallons per day present maximum capacity, and storage on the Tuolumne River sufficient to provide a present minimum supply during the driest year of 160,000,000 gallons per day, at an estimated cost of $36,981,000. The ultimate capacity of the project is to be 400,000,000 gallons per day, and the great altitude of the source (3,800 feet) makes possible three water power sites along the route of the aqueduct.

The chequered career of the Hetch Hetchy project is explained largely by the fact that San Francisco is supplied at present by a private water company, whose water supply resources are not as yet fully developed; that there are several other available sources of supply; that the proposed project must in part involve the development of

Table 1.—Growth in Population Supplied with Filtered Water in the United States by Slow Sand and by Rapid Sand Filters.

Year.	Total Urban Population in the U. S. (Towns and Cities above 2,500).	Pop. Supplied with Filtered Water. Slow Sand Filters.	Rapid Sand Filters.	Total.	Per Cent. of Urban Pop. Supplied. Slow Sand Filters.	Rapid Sand Filters.	Total.
1870 ...	....	None	None	0	0.00	0.00	0.00
1880 ...	13,300,000	30,000	None	30,000	0.23	0.00	0.23
1890 ...	21,400,000	35,000	275,000	310,000	.16	1.29	1.45
1900 ...	29,500,000	360,000	1,500,000	1,860,000	1.22	5.09	6.31
1904 ...	32,700,000	560,000	2,600,000	3,160,000	1.71	7.95	9.66
1910 ...	38,350,000	3,883,000	6,922,000	10,805,000	10.13	18.05	28.18
1914* ..	42,500,000	5,398,000	11,893,000	17,291,000	12.70	27.98	40.68

*Compiled January, 1914, by George A. Johnson.

a supply on government lands, and located in a National Park, and that the riparian rights of irrigation interests on the same river are involved.

Other Water Supply Developments.—The recent development of the larger supplies drawn from the Great Lakes has been influenced by the attempt to eliminate turbidity, and to secure more uniformly potable water by extending intakes to greater distances from the shore and to greater depths of water. Chicago, Milwaukee, Cleveland and Buffalo have attempted in this way to improve their supplies. Some benefit has been secured, but the remote intake does not insure pure water and does not give entire relief from turbidity at times of great storms. With the increasing pollution of the lakes, and the growing demand for pure, clear water at all times, the tendency of thought at present is towards the filtration of lake supplies. This tendency is shown by the use of filtration at Niagara Falls, N.Y.; Sandusky, Ohio; Erie, Pa.; and more recently at Evanston, Illinois; Cleveland, Ohio, and Toronto, Canada.

Many of our large cities continue to draw their water supply by pumping direct from near-by rivers, and the increase in quantity of water used from this source has been very considerable during the past ten years. The water supply problem for these cities has been greatly simplified by the present efficient methods of water purification, and practically all of our important river cities using river water have within the past ten years resorted to filtration. Among these cities are New Orleans, St. Louis, Minneapolis, Louisville, Evansville, Cincinnati, Pittsburgh, Philadelphia, Washington, and many smaller cities.

There have been many recent extensions of ground water supplies throughout the country, although the development of this source of supply has been advisable as a rule only in the smaller cities, and on a comparatively small scale. In some cases, as at La Crosse, Wis., a ground water supply has been developed, and the river supply abandoned to avoid filtration. In other cases, as at Des Moines, Ia., a satisfactory ground water supply has been extended, in preference to developing a river supply, with filtration. In still other instances, as in the case of the bay cities of California, ground water supplies have been extensively developed to supplement a very scant impounded supply, in a region where no rivers for water supply are available except at great distance.

With the continued growth of our urban population and the high rate of water consumption so characteristic of American cities, the problem of an adequate source of supply will continue to be a vital one for many of our cities, which are, as a rule, provided only for the immediate future, and will before many years, outgrow their present supplies. In certain sections of the country the limited water resources are without doubt a serious handicap to cities already existing, but where the growth of the city is sufficiently sustained we may expect to see other great water supply projects undertaken as at New York and Los Angeles.

Quality of Water for Municipal Supply.—Great improvement in the quality of the water furnished in many of our cities has been brought about during recent years by the introduction of supplies from pure sources and the purification of suspected supplies. The best general index we have of the extent to which our water supplies are better to-day than ten years ago, is still furnished by the typhoid fever death statistics, cautiously used. The typhoid death rate has, in nearly all cases, been greatly reduced, but in considering the effect of purer water supplies on the typhoid fever death rate, we must make due allowance for the decline in typhoid fever deaths from other causes now active.

It has been shown by Mr. George A. Johnson, Mem. Am.Soc.C.E., that we may reasonably attribute to water purification an average reduction of 16 deaths per 100,000 population in the thirty-three cities of over 100,000 population in 1910, that have introduced some form of artificial water purification. On this basis 2,600 typhoid-fever deaths are now avoided each year in these cities alone, and the saving in typhoid fever cases is estimated at 39,000 a year for these same cities. These conclusions are based on the typhoid statistics for the period 1900-1912, by comparing the average rate for 1900-1908 with the average rate for the period 1909-1912. Considering the increase in population supplied with filtered water since 1912, and the large number of cities and towns under 100,000 population having some form of water purification, it is evident that the above estimated saving of 2,600 typhoid fever deaths per year is probably much below the present total annual saving that has been brought about by the progress of water purification in the past ten years.

But the sanitary quality of our water supplies has also been generally improved by the close attention given to their quality in recent years, and the higher sanitary standards which an educated public has come to demand. More care is given to the protection and policing of watersheds, to the protection and cleaning of reservoirs, to the accidental contamination of lake supplies from shipping, and to the accidental contamination of surface supplies from railroad trains. Well protected ground water supplies have been sought for diligently as a superior source even to filtered surface waters, which depend, to some extent, on human vigilance for their purity, and the protection of ground waters and even deep well waters has been carefully studied. In all of these ways our general

standard is higher and our water supplies distinctly better than they were even a decade ago.

A number of cities having supplies of naturally very hard waters, like Columbus, Ohio, have in recent years installed water softening plants as well as filtration, while at other plants iron removal, or removal of color, is accomplished as part of the purification process.

Water Filtration.—Stimulated by wide dissemination of modern ideas of sanitation, water filtration in the United States has made great progress during the past decade. The population supplied by filtered water, as shown by Table I., has increased from 3,160,000 in 1904, to 17,291,000 in 1914. As late as 1903 only about 60 cities and towns were supplied with filtered water, while there are now some 480 filter plants in this country with a total capacity of 2,585,000,000 gallons per day. These filters serve 40.68 per cent. of the urban population, while in 1904 only 9.66 per cent. of the urban population (Including all towns of over 2,500 population) was so supplied.

The relative growth of slow sand and rapid sand filtration during this period is interesting. It reflects strongly the relative adaptability to conditions in this country of the two types of filters and the gradual acceptance by the general public of ideas in water purification looked upon with prejudice less than ten years ago. Although slow sand filters were the first to be introduced, by 1904 rapid sand filters, including the earlier "mechanical" filters were far in the lead with a total population served of 2,600,000, as against only 560,000 supplied by slow sand filters. From 1904 to 1908, several very large slow sand filter plants were completed, at Philadelphia, Pa., Washington, D.C., and at Pittsburgh, Pa., and the relative lead of rapid sand filters was much reduced, although even then the population served by rapid sand filters was very nearly twice that supplied by slow sand filters. Since 1910, the growth of slow sand filters has been less marked. In 1914, a population of 5,398,000 received water from about thirty slow sand filters, while upwards of 450 rapid sand filters supplied a total population of 11,893,000.

Although there are now in this country fifteen rapid sand filter plants to one slow sand plant, the capacity of the larger slow sand filter plants is greater than that of any rapid sand filters yet built. The largest slow sand filter, located at Philadelphia, and in service since 1908, has a rated capacity of 240 million gallons per day. In contrast to this, the rapid sand filter at Cincinnati, completed in 1907, with a capacity of but 112,000,000 gallons per day, is the largest plant of this type in operation up to 1915. Present tendencies in this country are indicated by the fact that several cities are now building mechanical filter plants larger than any now in operation, while no large slow sand filter plants are under construction or projected. A rapid sand filter of 320 million gallons capacity, 30 per cent. larger than any existing slow sand plant, has been designed for the Croton water supply of New York. St. Louis is building a rapid sand filter of 160,000,000 gallons capacity, the city of Cleveland is building two rapid sand filters, with a combined capacity of 225 million gallons, the larger plant of the two having 150 million gallons capacity, and Baltimore is about to complete a rapid sand filter of 128 million gallons capacity.

The rapid sand filter has outstripped the slow sand filter principally because it is better adapted to handling waters of the high turbidity characteristic, at times, of practically all our rivers outside of the extreme northwesterly portion of the United States. In many parts of the country, the slow sand filter, unaided by auxiliary processes, more especially coagulation and preliminary sedimentation, would be incapable of continuously handling the water except at greatly reduced rates of filtration, owing to the rapid clogging of the beds and great difficulty and time required in cleaning. The rapid sand filter, using coagulation and ample preliminary sedimentation that relieves the filters proper of a very large share of the burden of purification, and with easy means of cleaning the filter beds, has, on the other hand, repeatedly demonstrated its ability to properly and economically filter the most turbid waters. The growing recognition by engineers of the merits of the rapid sand filter is evidenced by the final recommendation in a number of instances of rapid sand filters, reversing earlier recommendation of slow sand filters, as in the case of New York City, Baltimore and Minneapolis.

Although the limitations of slow sand filtration in handling waters of high turbidity were early realized, these filters were often favored in preference to rapid sand filters. Popular objection to rapid sand filtration arose on account of its use of a coagulant. This prejudice is well illustrated in the case of Washington, D.C., where popular agitation resulted in the building in 1905 of a slow sand filter after the original recommendation of a rapid sand filter. Prejudice against the use of alum, and, in fact, against the use of other chemicals, either for coagulating, softening, or sterilizing water has now been for the most part overcome. This is mainly due to the extensive use of coagulation at a large number of rapid sand filter plants, occasionally in conjunction with water softening, without ill effects on the consumer, and to the well-earned public favor enjoyed by the process of water sterilization by means of hypochlorite of calcium.

While the rapid sand filter has overcome the prejudice under which it labored ten or fifteen years ago, and has been demonstrated as equal, if not superior, in bacterial efficiency to the best slow sand filters, it is of interest to note that the attempt in recent years to apply slow sand filtration outside of its proper zone of relatively clear natural waters has not met with success. This attempt has brought about very radical departures from early slow sand filtration practice, and has obscured the original sharp distinction between this type and the rapid sand filter, without evolving a superior filter. It has been necessary to resort to coagulation at the Washington slow sand plant, in spite of very long preliminary sedimentation. At Philadelphia and at Albany, preliminary filters, which are practically rapid sand filters, have been added to better enable the slow sand filters to do the work originally expected of them. At Pittsburgh extensive modifications have been necessary to properly prepare the water for the slow sand filters that had been proved incapable, alone, of producing a satisfactory effluent. The reliance now placed on sterilization of the filtered water at most of the principal slow sand filter plants shows further the wide departure made from the original slow sand process, in the effort to keep the performance of some of these plants up to the standard originally intended of them without the help of these and other auxiliary processes. All of these processes are foreign to the original idea of a "natural" process for water purification, which gave to the slow sand filter much of its vogue and played an important part in meeting the early competition with the so-called "mechanical" filter and the present rapid sand filter.

The process of rapid sand filtration was highly standardized ten years ago, and has undergone little change since 1904 beyond the incorporation of water sterilization as an additional safeguard, and a more gen-

(Continued on page 112.)

THE MAPPING OF CANADIAN CITIES.

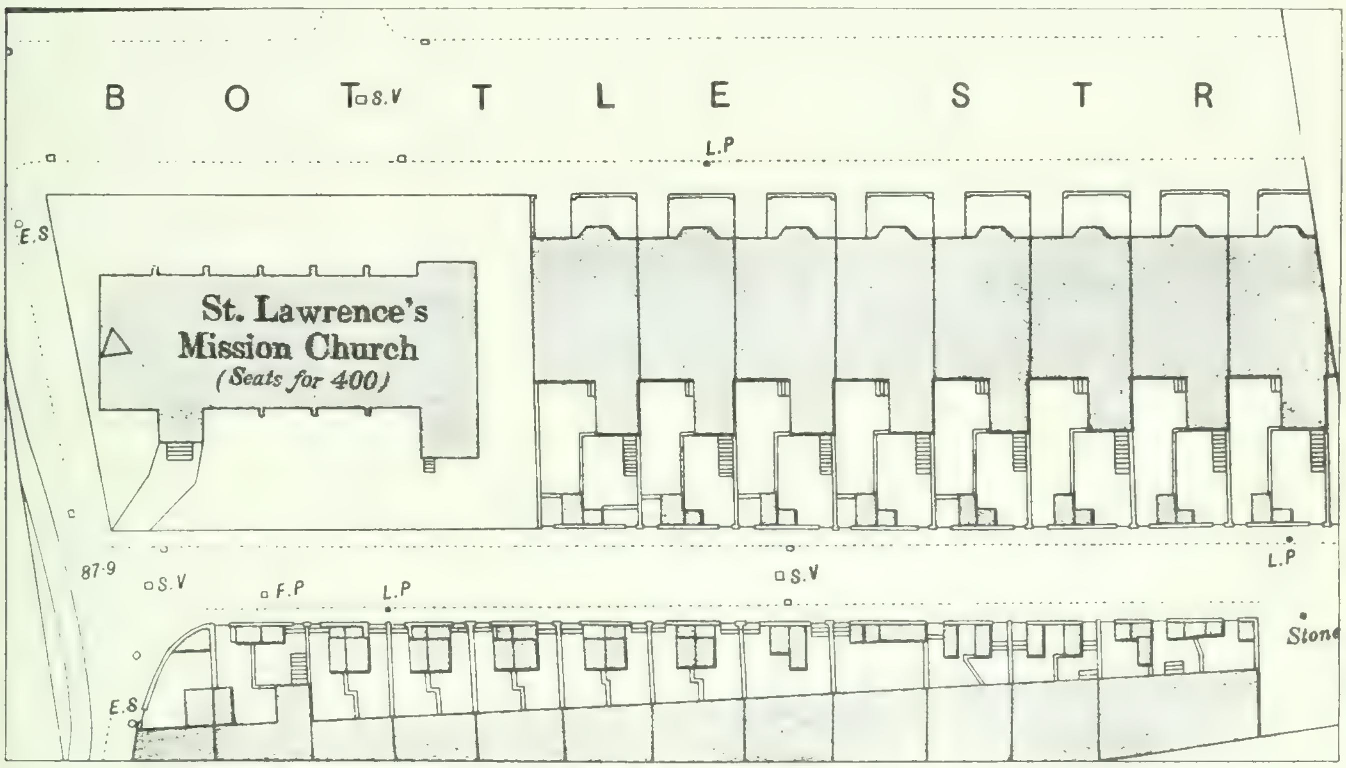
By Douglas H. Nelles, D.L.S., M. Can. Soc. C.E.

We have in Canada a very important commission. It is called "The Commission of Conservation." It is not executive in character, but is an advisory body. It collects and tabulates accurate information upon the natural resources of Canada, including Fisheries, Game, and Fur-bearing Animals, Forests, Lands, Minerals, Public Health and Town-planning. If we analyze each of these branches we will find that when brought down to their basic principles they all deal with "The Conservation of Human Life."

The most important branch of the commission's work is, therefore, the Town-planning branch, dealing, as it does, with human life in its most concentrated form. The health, intelligence and morality of the community depend upon the health, intelligence and morality of the individual, and this is to a great extent the result of the environment in which the individual lives and grows to manhood. Town-planning has, then, for its basic object the betterment of the individual through improving the environment in which he lives. That is to say, laws are passed which enable those who preside over the future destinies of the city to so control and regulate the growth of the city that the residential portions shall be in the localities most suited for healthy homes, that the homes themselves shall be built properly and not crowded, that the business section shall be in the most suitable situation, and that the manufactories shall be kept in the locality best suited to them.

In planning the localities for the different kinds of activities of city life various detail problems enter into the problem as a whole, such as transportation, involving location of railway tracks, yards and terminals, in regard to both passenger and freight service; rapid transit and street car service; the direction and width of roads; reclaiming of low and swamp lands and turning them into healthy parks and lakes; the location of sewers and water service, and many other problems which will be mentioned later on.

In order that the planning may be done in the most intelligent, systematic and economical manner it is absolutely necessary that there should be a large-scale topographical map of the city and the surrounding district which come under the town-planning scheme. There should also be a smaller scale map, published upon a scale of about six inches to a mile. The six-inch map is for planning the scheme in its general outlines, and the large-scale map is for working out the detailed problems of the scheme and the engineering problems encountered when the plan is put into action. Besides town-planning, these maps will form the basis of all the work and records of the city's engineering department, and also other city departments.

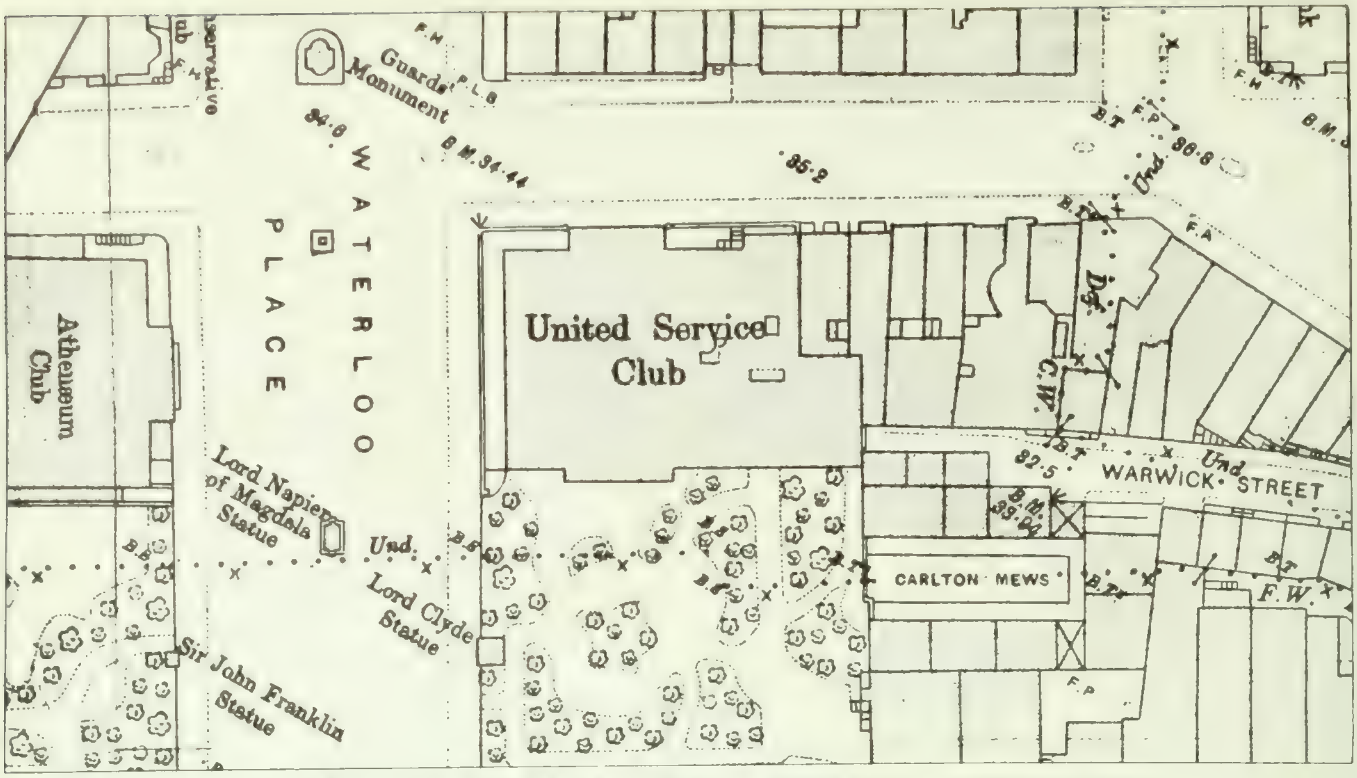


Specimen of the City of London, England, Map, 1/500 Scale. Published in Black.

The mapping of cities and towns in Canada on a large scale has not yet been attempted, but it is most important that such maps should be prepared as will be shown during the course of this article. This is especially so "because of the extent to which land has been subdivided beyond the limits of built-upon areas of most of our Canadian cities."

SCALE OF MAP.

Uses of Map.—In deciding what scale the map is to be published on we must examine the different purposes for which it will be used. They may be enumerated in part as follows: For city planning, for planning relief and storm sewers, or a complete sanitary system and the location of disposal works, for planning and laying out a complete water system or extensions, for locating new roadways, laying out subdivisions, for improving



Specimen Map of the City of London, England, 1/1056 Scale. Published in Black.

creeks, for landscape and parks works, for bridge works, for railways, their terminals and yards, for tunnels and canals, for gas pipe lines, for electric wiring lines, for telephone lines, even for architectural work, and many other purposes too numerous to mention.

It will be seen from the foregoing that the uses to which a city map will be put are many and varied. The waterworks engineer will have a complete set upon which he will show all his water and sewer lines. The road and sidewalk department, the driveway and parks department, the gas companies, the electric companies, the railway companies, the telephone companies, and many other smaller concerns and private individuals will each have a set upon which they can show such work as is already completed, and also design and calculate the cost of new extensions.

Specimen of an English Map on a Scale of 1/10560. Published in Black.

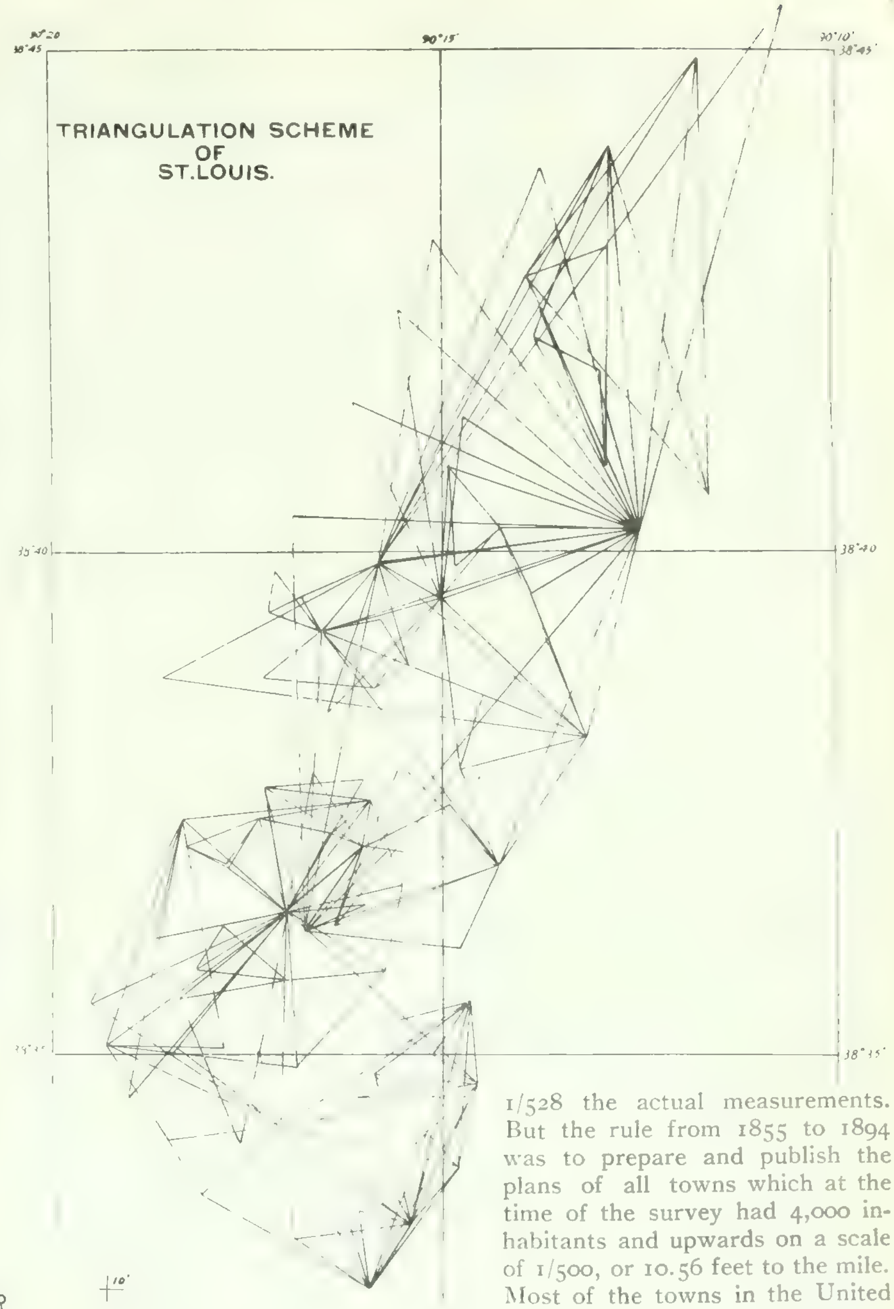
Data Shown on Map.—Having examined the uses to which the map will be put, we find that it will be necessary in order that it will be of the greatest value to all for it to show the following data: Buildings, sidewalk and road lines, trails and foot-paths, fences, boundary lines, railroads, canals, streams, rivers, lakes, tunnels, bridges, dams, locks, wharves, docks, jetties, breakwaters, ferries, fords, falls and rapids, marsh, hydrants, manholes, drainage grates, trees, triangulation stations, primary traverse stations, bench-marks, located land monuments, and the elevation and form of the ground surface by means of contours. It should also show the difference between public buildings, business buildings and residences.

And finally, before deciding upon the scale of the map, let us see what other countries have done in this respect.

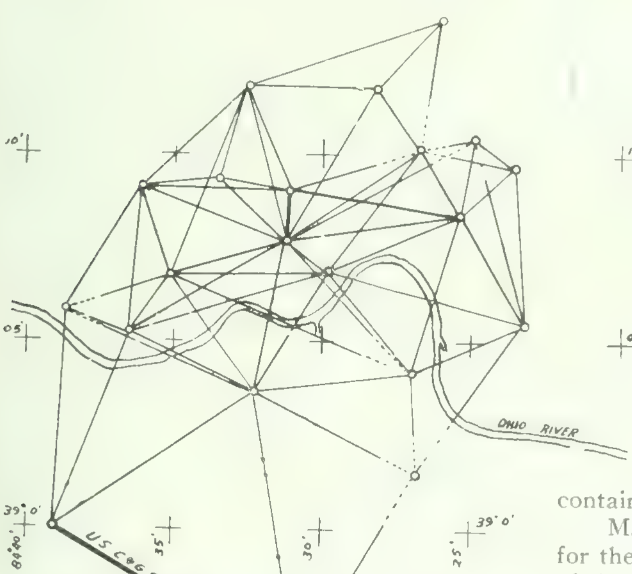
Memorandum on Large-Scale Maps of Great Britain.—"Town maps of the whole of the United Kingdom have been prepared on various scales. In England and Wales 408 towns, and in Ireland 105 towns, have had plans prepared and published in the ordinary course of the survey on large scales; and, in addition to these, large-scale plans of 33 smaller places in Ireland have been prepared but not published.

"The first scale adopted was 5 feet to a mile, or 1/1056 the actual measurement on the ground; the plans of London, Dublin, Belfast, and some smaller towns are still on this scale, and the original plans of the towns in Yorkshire, Lancashire and the South of Scotland were prepared and engraved upon this scale.

"There are also a few places that have plans on the scale of 10 feet to a mile, or 1/528 the actual measurements. But the rule from 1855 to 1894 was to prepare and publish the plans of all towns which at the time of the survey had 4,000 inhabitants and upwards on a scale of 1/500, or 10.56 feet to the mile. Most of the towns in the United Kingdom, therefore (London, Dublin and Belfast being, as above said, exceptions), have plans on this scale, which is large enough to show doorsteps, the thickness of walls, and the divisions of buildings. Most of the town plans also show all objects connected with water supply, lighting and drainage, such as hydrants, sewers, manholes and gratings. Levels are shown along the streets and bench-marks are cut at frequent intervals, showing to two places of decimals the altitudes above mean sea level. Areas are not shown on the town plans."



TRIANGULATION SCHEME OF ST. LOUIS.



TRIANGULATION SCHEME OF CINCINNATI

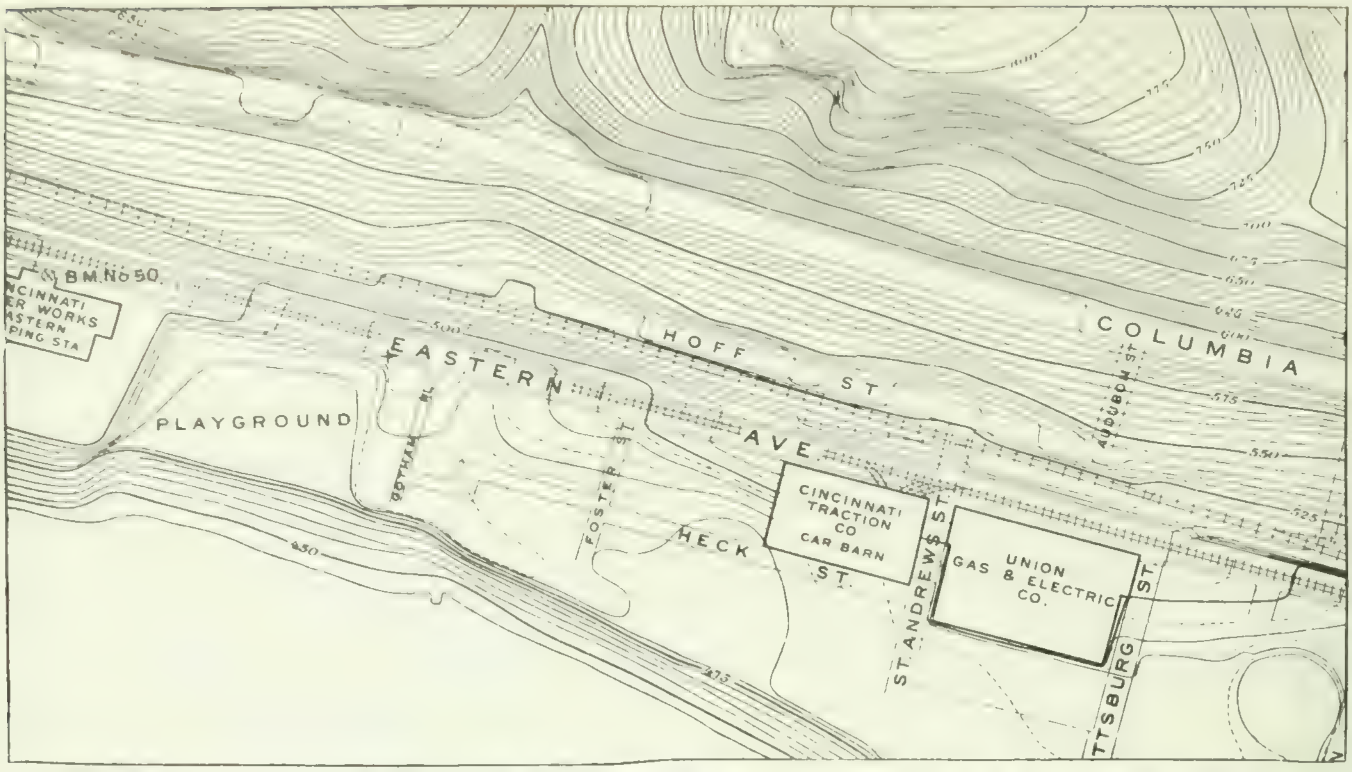
The plans on the scale of 1/500 are similar in size to the 1/2500, or 25-inch plans, namely, about 36 x 25 inches, and contain an area 24 x 16 chains, or 38.4 acres.

Maps on a scale of 1/2500, or 25.34 inches to the mile, are published for the whole of the cultivated districts of Great Britain, and the survey of the cultivated portions of Ireland is in progress.

Maps on a scale of 1/10560, or six inches to the mile, can be obtained for the whole of the United Kingdom.

Map of St. Louis, U.S.A.—This map is on a scale of 1 inch equals 200 feet, or a natural scale of 1/2400, with a contour interval of 3 feet.

Map of Cincinnati, U.S.A.—This map is on a scale of 1 inch equals 400 feet, or a natural scale of 1/4800, with contour intervals of 5 feet and



Specimen of the City of Cincinnati, Ohio, Map, 1/4800 Scale. Published in Black, Blue, Brown and Green.

2½-foot contours when the slope is less than six degrees.

Suggested Scale for Canadian City Maps.—A scale of 1 foot equals a thousand feet, or a natural scale of 1/1000, would enable us to show all the necessary detail. It would be an easy scale for an engineer to make calculations from, a scale economical from the standpoint of the topographical surveyor, and one from which measurements could be taken either in feet or meters; and, as the metric system of measurement is coming more and more into use by scientific men, we should provide for future changes in this respect. It would, therefore, seem that the 1/1000 scale would be the best for Canadian cities, lying as it does half-way between English practice of 1/500 scale and the American practice as represented by the Cincinnati map on a 1/4800 scale.

METHODS OF SURVEY.

Triangulation. — In all surveys for map-making, where there is any considerable area to cover it is necessary to have a scheme of triangulation, making a network over the territory to be mapped. Triangulation is generally divided into three classes, Primary, Secondary and Tertiary.

Primary triangulation is the most accurate known method of measuring long distances, and is used for co-ordinating detached surveys and for computing the figure and shape of the earth. It consists of a scheme of triangles whose sides are from 10 to 100 miles in length. The angles are read with an instrument whose microscopes read to the tenth part of a second. The three angles of each triangle must add up to within one second of 180 degrees, plus the spherical excess, and the side equations must be so that the average absolute error must be less than 0.4 of a second before the field-work is accepted by the geodesist's office. Base lines of from six to ten miles long are measured approximately every 150 miles apart to check up the accuracy of the distances. In measuring a base line an invar tape is used, and great care is taken throughout the operation to insure such accuracy that the probable error in the mean of the several measurements shall not be more than about one part in 2,000,000.

Laplace points are also put in about 150 miles apart. In the adjustment of the triangulation they take out what is called the "twist" of the scheme. They consist of geodetic triangulation stations at which precise observations for longitude, and azimuth to another station, have been made.

The Geodetic Survey of Canada has now a scheme of primary triangulation extending over most of the settled parts of the Eastern Provinces. The data concerning the stations which have been adjusted and computed may be had by applying to the Survey.

Secondary triangulation is based upon the primary work, and is generally less accurate than primary work. The sides of the triangles are from 2 to 10 miles long, and the triangles are required to have an average closure of between 2 and 3 seconds. An instrument reading to 10 seconds is generally used.

Tertiary is the least accurate of standard triangulation. The length of the sides of the triangles are from one-quarter of a mile to ten miles. It is based on secondary or primary work, and is used to control topographical points in map-making on small scales. The triangles are required to have an average closure of from 4 to 5 seconds. An instrument reading to 10 seconds is generally used upon this class of work, although very good results can be got out of a minute instrument. In 1911, while working on the survey of the international boundary line between Canada and Alaska, the writer observed 18 triangles with a four-inch Berger theodolite reading to single minutes, and had an average closing error of 4 seconds per triangle.

In city surveying, it is the general practice to do the triangulation with a primary instrument and with primary methods. A main scheme of quadrilaterals is laid out over the district, and from the main stations a large number of intersections are observed, so that altogether there are located about two stations per square mile. These triangulation stations now form the main control points. The error in distance between any two of them should be less than one inch. All other lineal measurements in connection with the making of the map are tied on to them and the closing error of the line distributed along the line between starting and closing stations.

The adjusting of the triangulation should only be done by a competent adjusting staff, such as is engaged in that work under the direction of Maxwell Tobey, geodesist, and assistant superintendent of the Geodetic Survey of Canada. The methods used are those known as the "Method of Conditions" and the "Method of Co-ordinates."

The city triangulation schemes would be based upon the Primary Triangulation of Canada.

Traverses.—Parallel main traverse lines should be run about half a mile apart in the centre of the city where it is thickly built up, and about a mile apart in the outlying districts where it is thinly settled. They should be tied in to triangulation stations about every half-mile. In computing the traverse, the bearings of the courses are first adjusted so as to give as nearly as possible the true astronomical azimuth at each station. The latitude and departures are then computed and adjusted between the triangulation stations.

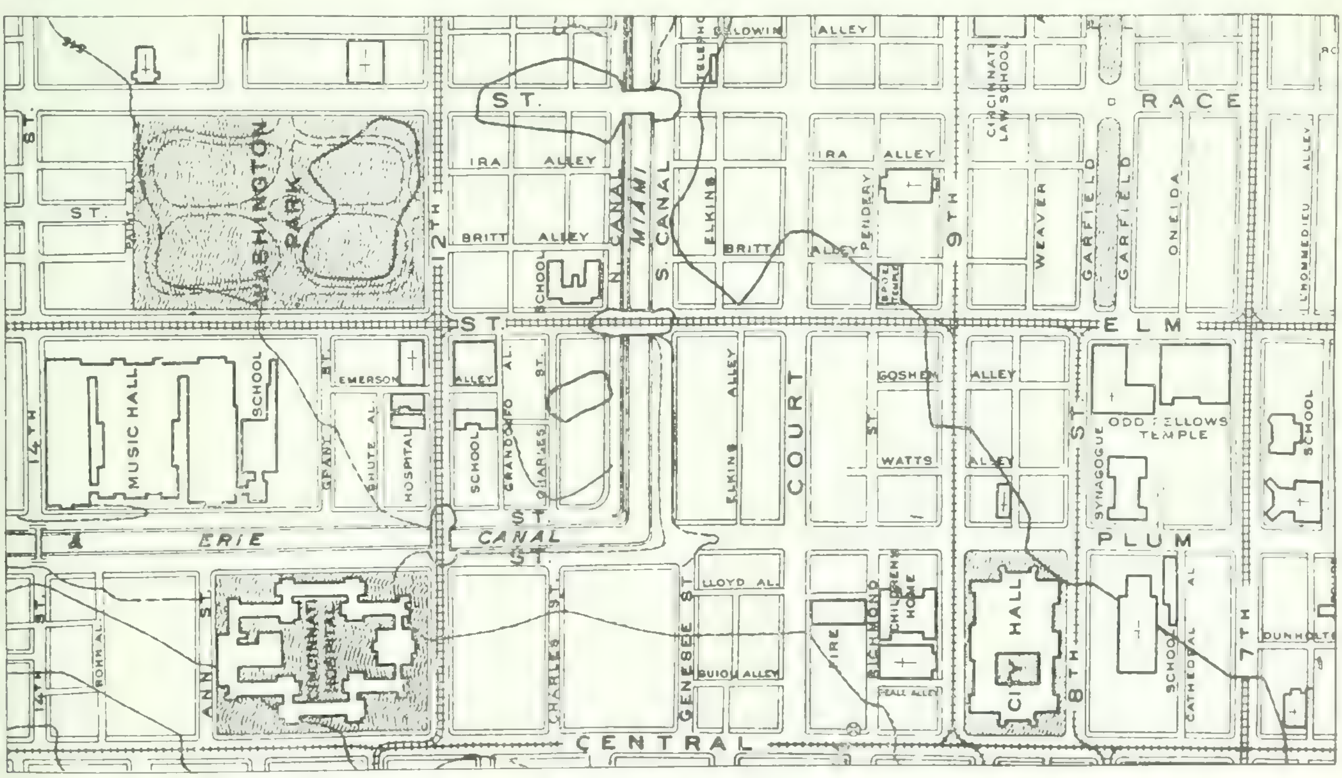
After the main lines have been surveyed, secondary lines are run down parallel streets, starting from, and ending on, a station of the main lines. They should be run just as accurately, adjusted and computed in the same manner as the main lines, but are not necessarily connected directly with triangulation stations.

Too much cannot be said about the importance of leaving permanent survey marks. It very often happens that an expensive survey is made and no permanent marks left upon the ground. The only results of such a survey would be its plan or map. In many cases when certain information is wanted and it becomes necessary to make another survey, a large amount of resurveying is done that would not have had to be done if permanent marks had been left on the original survey. It is, therefore, advisable that permanent marks, consisting of a small bronze bolt, ¾ in. in diameter and 3 in. long, be put in the concrete sidewalk at every street corner to mark the traverse stations.

The traverse routes should be so chosen as to give the shortest length of traverse line. What is meant by this is explained by Fig. 1. In most cities the blocks are oblong, as in the sketch. In this case the main traverse lines should be east and west and the secondary north and south.

Fig. 1.

The angles should be read with a 10-second vernier transit by a single, direct and reversed reading, and reading both verniers in such a way as to give the bearing of the forward course. When the reversed readings are finished the instrument is left clamped,



Specimen of the City of Cincinnati, Ohio, Map, 1/4800 Scale. Published in Black, Blue, Brown and Green.

and when taken forward to the next station and the telescope pointed to the back picket in the direct position, the verniers will read the correct bearing of the course.

The chaining should be done with a 100-foot steel tape. When chaining on slopes the angle of slope should be measured and a correction applied. A thermometer should be attached to the end of the chain and a reading taken at the end of each course.

Precise Levelling.—It is the general practice in city surveying to cover the city with a scheme of geodetic or precise levels. In planning this scheme reference should be had not only to the needs of the topographic survey, but also to the future needs of the city's engineering department. In the Cincinnati survey the precise bench-marks averaged 2.2 per square mile. In St. Louis they averaged 12. per square mile. For Canadian cities, if a circuit were run around the outside of the district, parallel lines one mile apart run across it, and connected with the circuit at both ends, and bench-marks set at every half-mile, it would make a very complete system.

Secondary or engineering levels would then be run between precise bench-marks and over the traverse lines, thus making every traverse station a bench-mark. All existing bench-marks of the city engineering department would be tied in by these secondary levels and their elevations reduced to mean sea level. Extra bench-marks would also be put in where it seemed necessary. As the geodetic survey of Canada now has one or more geodetic bench-marks situated in nearly every city of Canada, the geodetic level scheme for each city would be based upon them.

Topography.—In the business section of the city the topography would be taken by a chained survey, similar to the English system of tieing in buildings. For the residential district, parks, open ground and outlying districts the plane-table would be used. Street lines, road fences, and sidewalks would be tied in when the traverse was chained. Contours would be shown at five-foot intervals or less.

In General.—"It should be borne in mind that in all kinds of survey work a reasonable degree of accuracy is a desideratum, but that no refinements should be introduced that would add greatly to the cost without increasing the practical value of the work."

METHOD OF KEEPING SURVEY RECORDS.

Field Notes, Abstracts, Adjustments, Computations and Results.—All the foregoing, excepting field notes, would be so systematized as to go on forms printed upon loose-leaf paper, 8½ by 11 inches in size, having seven holes punched in the left side so as to fit into the Mc.M. Multiple-ring loose-leaf book. This is the size that has been found to be most convenient for general purposes, and is the size of the ordinary business letter sheet. If it is absolutely necessary to have a form larger than this it would be made in a multiple of this size and when ready for filing folded down to size. Field notes would be kept in a specially devised loose-leaf book of a convenient size, with an arrangement for keeping the leaves flat against the covers. Loose leaves would be used to facilitate the system of the instrument-man, leaving each day's notes at the office for the stenographer to make the abstracts, which would be double-checked and a copy sent to the head office upon the completion of each line.

In connection with the loose-leaf system there would be a card index, through which, by a system of cross-reference, each particular kind of information could be approached from a number of different directions.

Keeping Track of Costs.—The chief of each field party would be required to turn in a weekly report, stating the details of each day's work. Each member of the office staff would be required to turn in a similar statement. From these statements the efficiency of each member of the staff would be determined and the detailed cost of each part of the work. From these records, after one city had been surveyed, it would be easy to make a very accurate estimate of the cost of making a map of any other city.

(Concluded in next week's issue.)

FOURTH DIVISIONAL CYCLIST CORPS.

No. 2 Detachment Corps of Guides, with headquarters at the Toronto armories, commenced this week to recruit for a Fourth Divisional Cyclist Corps, for active overseas service.

As the work of this corps will consist largely of mapping, reconnaissance, and preparing reports, men with engineering training are especially wanted.

Definite information may be obtained by writing Lieut. C. S. McKee, O.C. of the Detachment, or by interviewing any of the officers or N.C.O.'s at the orderly rooms in the armories, Tuesday or Thursday nights.

RECENT PROGRESS IN WATER SUPPLY.

(Continued from page 106.)

eral appreciation of the importance of preliminary sedimentation. Filters of this type follow closely the lines of the original modern rapid sand filter built in 1902 at Little Falls, N.J.

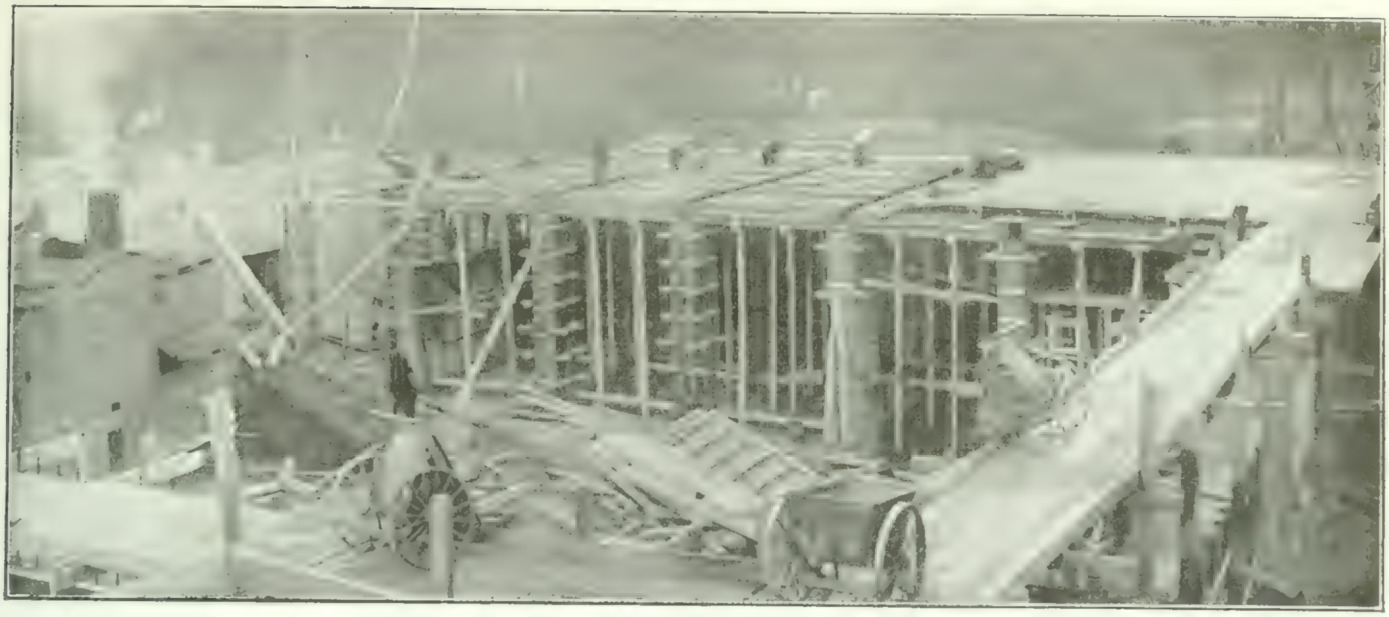
Although it is well understood that any filter has a definite limit of capacity beyond which it is not possible to obtain properly purified water, there is a tendency to operate filters at greater than the safe rates, as the plants are outgrown. The danger in this practice is evident, and engineers generally are disposed to discourage it, and, so far as possible, to anticipate it by designing with ample provision for the needs of the immediate future, and with special attention to facility for making future additions.

There is a further tendency of late to over-confidence in filtration as a preventative of disease, and a disposition in some quarters to attempt the filtration of badly polluted waters in preference to more expensive and distant sources. The engineer and the sanitarian of to-day are engaged in pointing out that it is not a proper or wise policy to overload water filters from a poor source of supply.

The field of possible application of water filtration, and more particularly rapid sand filtration, is to-day a very broad one. Practically all river and large lake municipal water supplies, and many impounded supplies, must eventually be filtered to meet the rapidly spreading demand for uniformly safe and potable water. We may reasonably look forward to an extension of water filtration during the next decade fully as great as the growth from 1904 to 1914.

(Concluded in next week's issue.)

At the ninth annual meeting of the Nova Scotia Society of Engineers, held at Halifax recently, the following officers were elected: President, J. L. Allan; first vice-president, W. S. Ayars; second vice-president, A. J. Barnes; secretary-treasurer, D. McD. Campbell.



General View of Tank Before Erection of Weir Walls; Roof Partly Constructed.

TANKS FOR TEMPORARY STORAGE OF STORM WATER

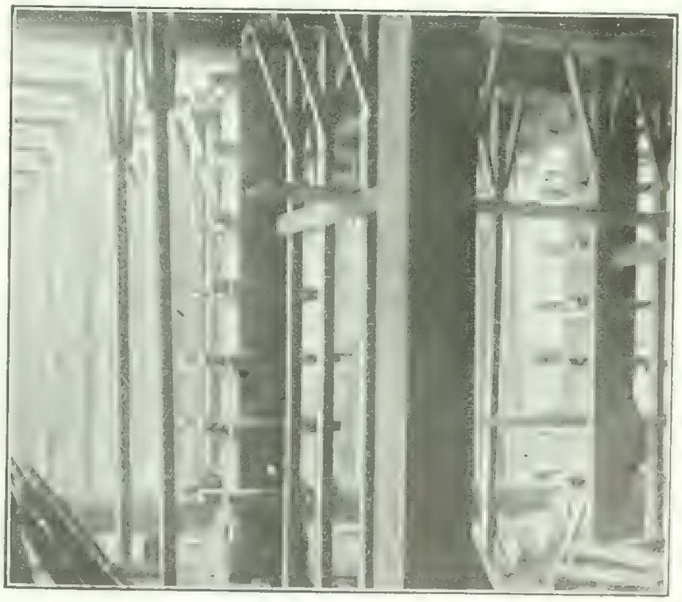
DESIGN AND METHODS OF CONSTRUCTION OF STAND-BY TANKS IN HIGH PARK, TORONTO—AFTER DETRITUS HAS SETTLED, ONLY VERY DILUTE WATER PASSES INTO LAKE ONTARIO.

By W. G. Cameron,
District Engineer, Sewer Section, Department of Works, Toronto.

THE West Toronto stand-by tanks are situated at the southwest corner of Keele and Bloor Streets in High Park. The site, which is the lowest ground in this neighborhood, is the bed of a small creek which crosses Keele Street immediately south of Bloor. The creek is nearly dry except for storm and spring flood water. Keele Street is filled in across this creek and is about 15 feet above the level of the present top of the tanks. A culvert is provided where the fill was made, and now discharges into the storm water outlet. The site was covered with small trees and scrub and in places was wet and boggy.

Purpose.—The object of the tanks is to provide a temporary storage for flood and storm water. If the volume of water is not too great for the capacity of the tanks, it is discharged gradually into the 18-inch sewer under the large storm water outlet, and carried eventually to the disposal works at Morley Avenue. In this way, the 18-inch sewer is not overtaxed. If, on the other hand, the volume of water is too great for the capacity of the tanks, the water is discharged over weirs into the large storm water outlet. But the tanks provide a temporary resting place where the detritus, etc., may settle, and, when the storm has subsided, may be drawn off in the 18-inch sewer, while only the very dilute water from the surface passes directly to the lake without being treated.

Inlets.—The inlet sewers were all built before the tanks were constructed, so the tanks formed the missing link in the system. There were three of these inlets, one from the west ("A" on Plan, page 115), one from the east (B) along Bloor Street, and one from the north (C) along Keele Street. C is a 7′ 6″ x 8′ 0″ concrete culvert, into which flows a 9′ 3″ circular sewer. The sewer from the west enters the tanks at the north end of the west side as a 6′ 9″ x 5′ culvert. The sewerage flows into a channel across the north end of the tanks, contained on the one side by the north wall of the tanks, and on the other by a weir. By means of this weir, the dry flow is guided into a small 2′ x 2′ 2″ culvert, which discharges into an existing 3-ft. sewer down Keele Street. The storm water passes over the weir into the tanks. If, at some future time, the 3-ft. sewer down Keele Street be overcharged, a 12-in. pipe sewer is provided, and, by opening a valve



Form Work in Place on Columns.

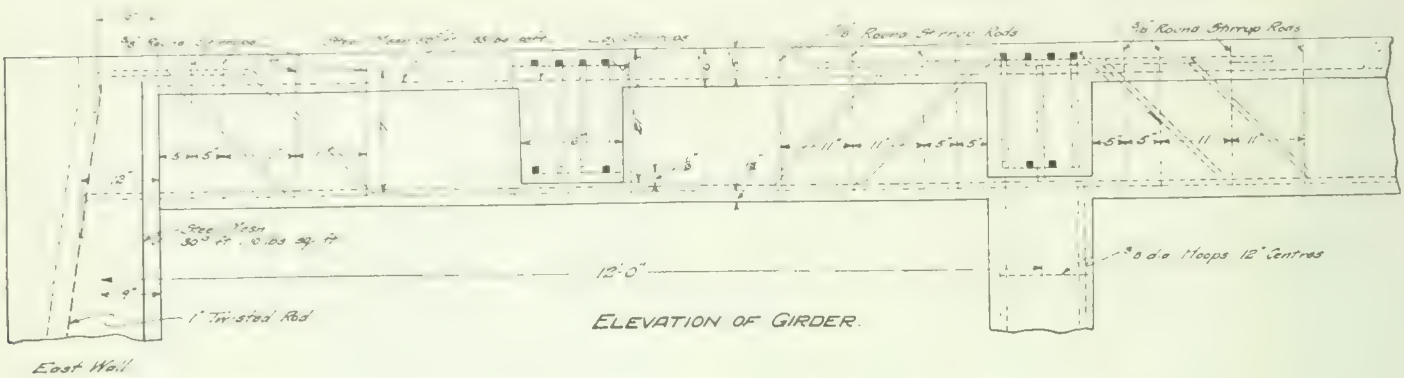
at the weir, the surplus can be drawn off through it into the 18-in. pipe under the storm water outlet.

The sewer from the east (B), 2′ 0″ x 3′ 9″, egg-shaped, enters the east side north of the centre. This sewer does not really empty into the tanks proper, but into the upper part of the storm water outlet. Even here, it is only overflow storm water that is discharged. The dry flow discharges into the 3-ft. sewer down Keele Street over which this Bloor east sewer passes.

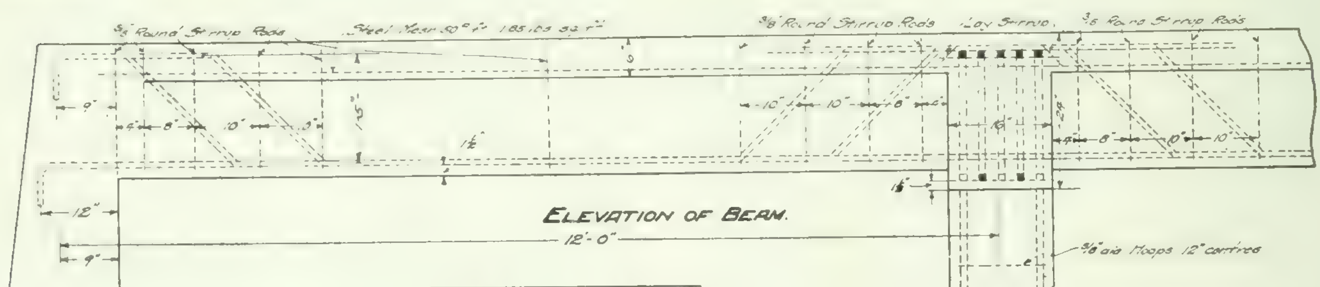
The sewer from the north (C) enters the tanks at the east end of the north side. One hundred and seventy-three feet north of the tanks a weir is provided in this sewer, by which the dry flow is diverted into a 24-in. tile pipe sewer (D) leading directly into the end of the 3-ft. sewer down Keele Street. This 24-in. pipe also has an overflow provided, in case at any time the 3-ft. sewer should be overcharged and back up into the 24-in. pipe. This overflow leads indirectly into the 18-in. sewer under the large outlet. The storm water from the north flows over the weir in C, 173 ft. north of the tanks, and into the tanks. Thus we see that the dry flow from all these inlets does not reach the tanks, but all discharges into the 3-ft. sewer down Keele Street on its way to the disposal works, while only the storm water finds its way into the tanks.

Design.—The tanks are rectangular in shape, and approximately 104′ x 112′. On the north side, there is a channel 3.5 ft. deep for the Bloor West sewer, separated from the tanks by a weir. This has been described above. On the east side, there is a section 4 ft. deep, separated from the tanks by a weir, and from the storm water outlet by another weir. Into the north end of this section the storm water from the Keele Street sewer flows. The bottom of this section is graded back towards the north end and a gate valve is provided which can be opened to allow the section to drain into the storm water outlet. The tanks proper are divided into three parts, 17½ ft. deep, by two weirs. These three divisions are graded towards the east side, where they drain into an open 18-in. sludge channel, which runs south along the inner side of the east wall and into the 18-in. tile sewer under the storm water outlet. A gate valve is provided at the end of the sludge channel at the south wall.

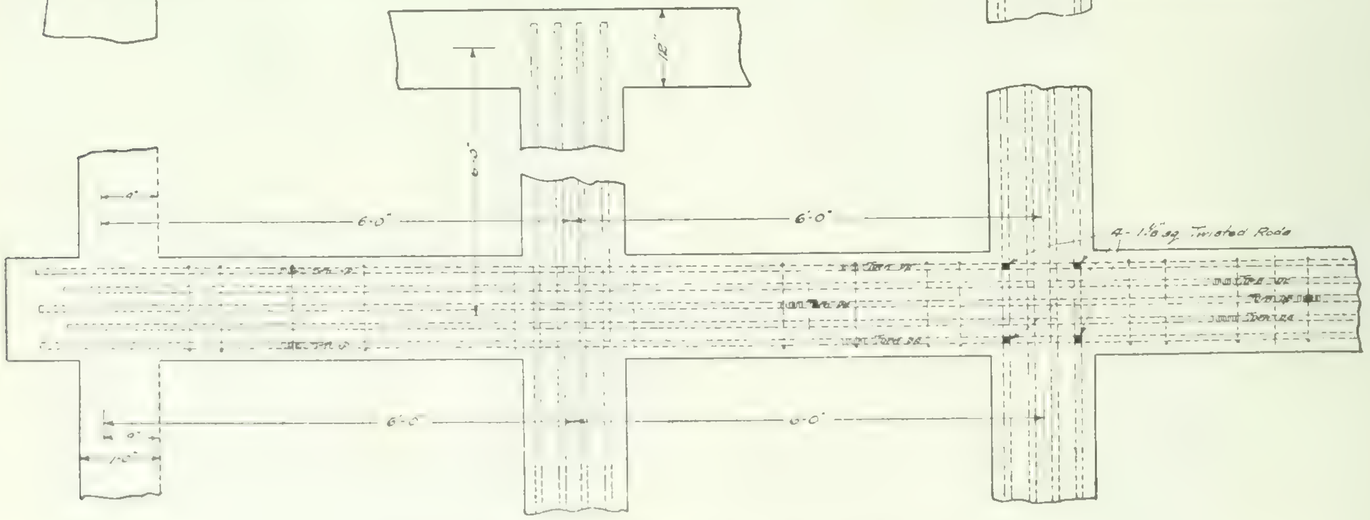
Eight rows of columns were used in the tanks for the support of the roof. These columns were 18 ins. square



ELEVATION OF GIRDER.



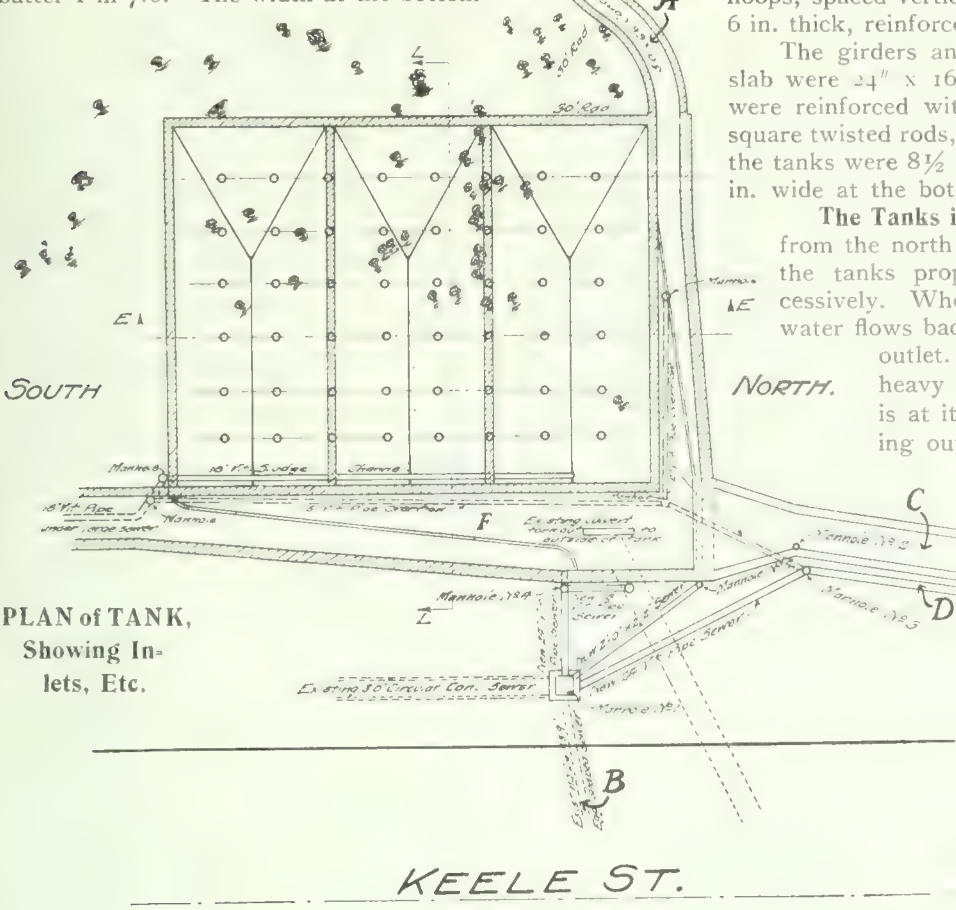
ELEVATION OF BEAM.



SECTIONAL PLAN THROUGH BEAM AND GIRDER.

in section, 12 ft. apart centre to centre in the rows and 12-ft. centres between the rows. Two rows of columns were in each tank, and one was used as support for each of the two dividing weirs. The tanks were built of all reinforced 1:2:4 concrete. The walls were 12 ins. wide at the top, while the sides had a batter 1 in 7.6. The width at the bottom varied as the height. There was a footing provided 2 ft. deep and 12 ft. 6 in. wide. The reinforcing for the walls was 1-in. square twisted rods on the outside and 0.30 sq. in. mesh on the inside. The columns were reinforced with 1⅛ sq. in. twisted rods, 2 ft. 6 in. long, as dowels into the footing, one 1⅛ sq. in. rod in each corner, the full height of the column, and ⅜ in. round hoops, spaced vertically 12 in. apart. The roof slab was 6 in. thick, reinforced with 0.5 sq. in. mesh.

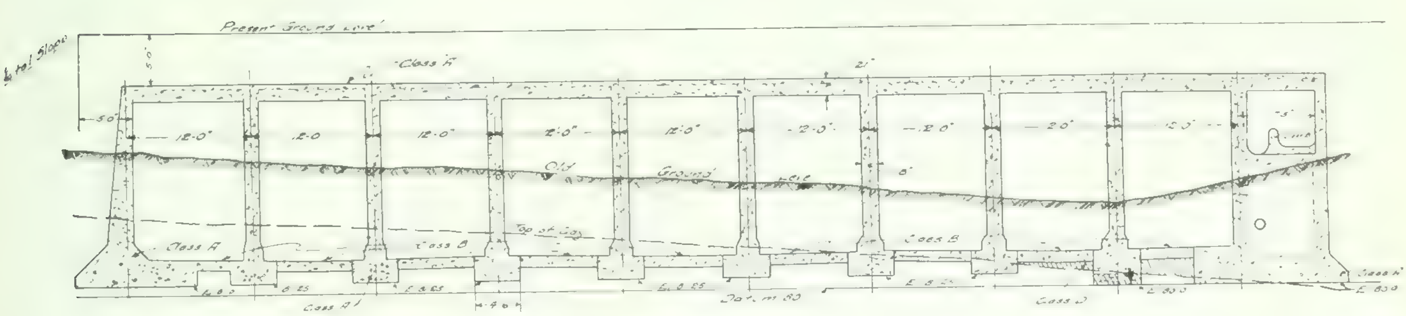
The girders and beams for the support of the roof slab were 24″ x 16″ and 21″ x 16″ respectively. They were reinforced with 1 sq. in. twisted rods and ¾ in. square twisted rods, respectively. The weir walls between the tanks were 8½ ft. high, 9 in. wide at the top, and 18 in. wide at the bottom, reinforced with ¾ sq. in. bars.



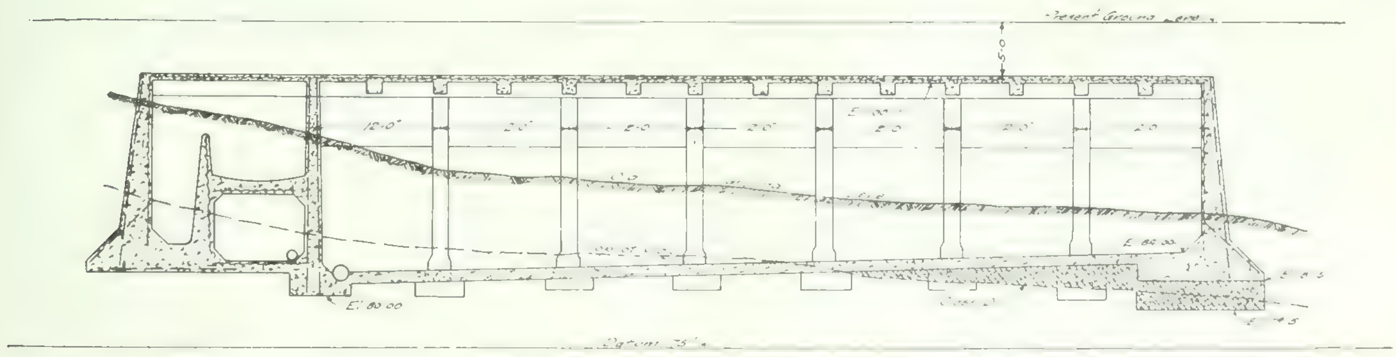
PLAN of TANK, Showing Inlets, Etc.

The Tanks in Action.—During a storm, the water from the north and west passes over weirs and into the tanks proper, filling the three divisions successively. When all three and section F are full, the water flows back over the weir into the storm water outlet. But this will happen only during a heavy storm, and then only when the storm is at its height. Therefore, the water passing out through the storm water outlet will be practically pure storm water.

In each of the three tanks there is a floating arm situated at the east wall, which floats on the surface of the water and collects any floating material and carries it into the 18-in. pipe under the storm water outlet. When the storm has subsided the tanks are drained, gradually, through the sludge channel into the 18-in. pipe. There is a water connection provided at the west end of each tank so that the tank may be flushed clean after it has been in use.

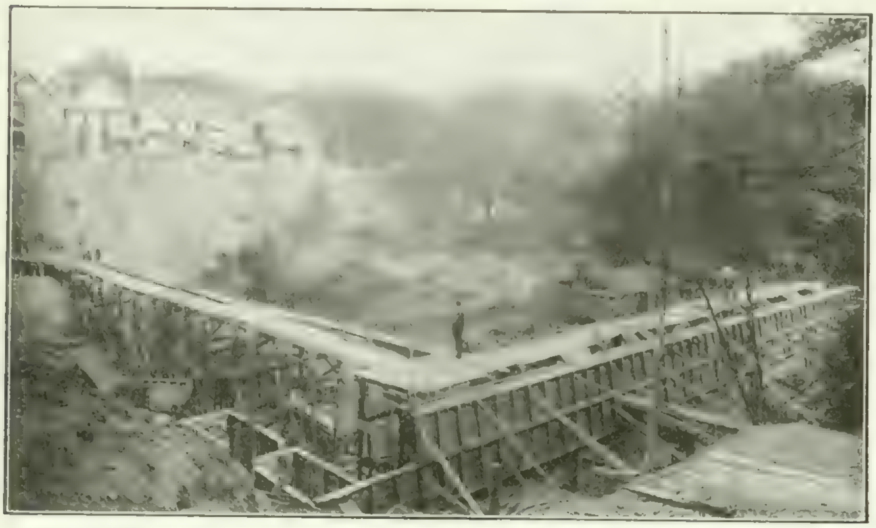


Section E-E.



Section L-L.

Construction.—The ground on which the tanks were built was composed of sand on the surface, which, in small areas, formed pockets. The sub-soil was hard, blue clay. Trenches were excavated by hand for the west wall and the western third of the north wall. This part was built first because the ground was low at this side. When these walls were built, and the concrete sufficiently hardened, they were used as a retaining wall for the next material excavated. This material was taken from inside the lines of the future tanks and next the west wall. Enough material was taken out to allow for the erection of a portion of the tanks on the west side. This portion was completed floor, columns, weirs and roof and allowed to harden. The next material excavated was then deposited on the roof of this finished portion. Thus the excavation and construction proceeded alternately from the west. A clam shell was used for excavating in the body of the tanks, but the clay was so hard that the most of it had to be loosened with picks before it could be gathered up by the clam.



View of Ground and Start of Work, Showing North and West Walls.

The concrete was all mixed by a drum mixer very conveniently placed at the top of the bank on Keele Street. The concrete was dumped into a chute which carried it down the bank to a funnel-shaped box. This box was provided with a slat which slid up and down so that concrete could be taken away in any quantity desired. The concrete was carried in concrete barrows along runways so built that they might be easily taken down and erected quickly again wherever they were required. The forms used for the concrete were all of the panel type. They were built near the work and the same sections used several times. They were made before the work was begun and grouped according to size, so that when they were needed they could be easily found and quickly erected. They were fastened together with bolts.

When the work on the tanks was completed the soil which had been excavated, and soil brought from other work, was spread over the top of the tanks to a depth of four feet. The bank on Keele Street was extended and neatly graded, and an easy slope was made from Bloor Street. The ground over the tanks and the slopes will probably be sodded and planted and possibly tennis courts, etc., arranged on it, making in all a very great improvement to this corner of High Park.

Costs.—The costs in hours' labor of this work, as kept by S. K. Ireland, B.Sc., resident engineer, are as follows:—

Excavation.—7,000 cu. yds., 10,472 hours, or 1.496 hours per cu. yd.

Placing Steel.—102 tons, 1,471 hours, or 14.4 hours per ton. (85 tons of this were bars and 17 tons mesh.)

Building and Erecting Forms.—52,899 sq. ft. took 8,452 hours, or 0.159 hours per sq. ft.

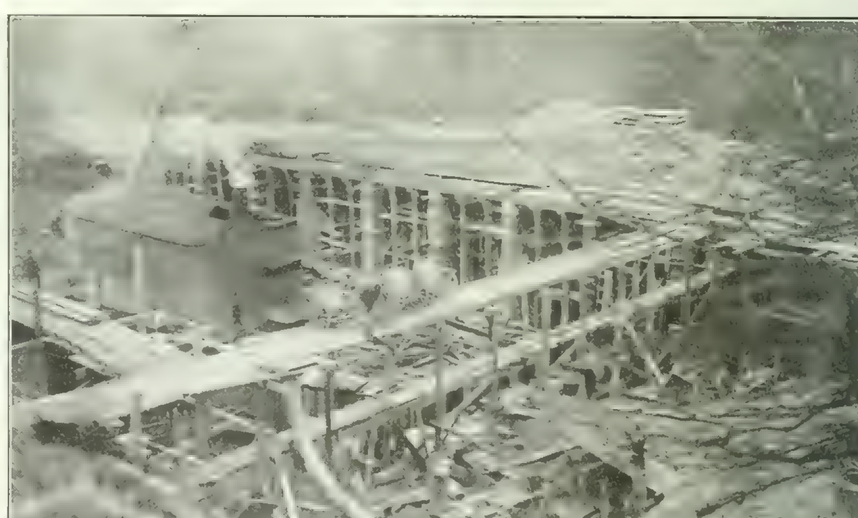
Removing Forms.—0.0202 hours per sq. ft.

Mixing and Placing Concrete.—2,522 cu. yds. took 6,394 hours, or 2.53 hours per sq. yd.

Foreman, 1,658 hours; engineer, 1,098 hours; fireman, 1,133 hours; team, 107 hours; single horse, 451 hours.

IMPERIAL OIL BUILDING.

At the corner of Church and Court Streets, Toronto, directly opposite to *The Canadian Engineer* building, foundations are being prepared for a large office building for the Imperial Oil Company, Limited. The structure will be of steel, with fireproofing throughout the seven stories and basement, all doors and trim being of steel, and windows of wired glass. The general contractors are Thompson, Starrett Company, 51 Wall Street, New York. Subcontracts have been let as follows: Structural steel, Dominion Bridge Company; masonry and fireproofing, Witchall & Sons; steel casements and trim, A. B. Ormsby Company; excavation, Ed. Corner, Toronto. The architects are Clinton & Russell, Dominion Bank Building, Toronto. The resident architect is Jas. L. Havill. The excavating contractor is using a revolving "Thew" shovel, ⅝ yard capacity, and a 12-h.p. "Beatty" hoisting engine, supplied by H. W. Petrie, Limited..



Showing Method of Disposing of Excavated Material; Also Runways for Concrete Barrows.

Editorial

THE KING HONORS CANADIAN ENGINEERS.

Engineers throughout Canada read the list of New Year's honors with the utmost satisfaction. It is doubtful whether the engineering profession in Canada has received ever before such marked recognition by our King. It augurs well for the prestige and social standing of engineers in this country, that three honors went to members of their profession, while the law received two; medicine, one; and finance, two.

Sir John Kennedy and Sir Collingwood Schreiber are the deans of Canadian engineering. Their knighthood is fully merited, and has been heartily acclaimed by all who are acquainted with them or their work.

To General Sir Alexander Bertram, *The Canadian Engineer* also proffers congratulations upon his well-deserved recognition. His long and distinguished career as an engineer and military officer is widely known. His capable organization of the shell-making facilities of Canada, which resulted in a saving of millions of pounds sterling to the British Government, in itself earned the honor he has received.

ONTARIO'S HYDRO-RADIALS.

Citizens of Toronto went to the polls last Saturday, and by their votes on a hydro-radial by-law, they gave engineers, contractors and machinery manufacturers the finest possible sort of a New Year's present. By a vote of nearly four to one, the taxpayers endorsed the agreement under which the city guarantees about $4,000,000 of the bonds of the proposed Toronto-London radial railway, to be constructed and operated by Ontario's Hydro-Electric Power Commission. By this vote the people of Toronto helped to make possible the future expenditure of upwards of one hundred million dollars on public improvements within the Province.

The Toronto vote was mostly a vote of confidence in Sir Adam Beck, and an expression of lack of confidence in the city council's ability to deal satisfactorily with Toronto's transportation problems. The average citizen probably knew little or nothing, and cared less, about the by-law which he ratified. He thought that private corporate interests opposed the by-law; therefore he was in favor of it. He felt that radial running rights through Toronto's streets are no more dangerous to his interests than are councilmanic vacillation and subdividers' schemes. But in voting for the by-law, he tied another string on corporate ownership of public utilities, and, incidentally, promised engineers and contractors in Ontario an immense amount of work within the next decade.

Not only will $14,000,000 be expended on the Toronto-London line, but that line will eventually be extended to Sarnia. Then there will be a line northward from Toronto, running to Collingwood, Barrie and Orillia, and possibly to Owen Sound. An easterly radial will run along the shore of Lake Ontario, right through to Montreal. All of these trunk lines will have feeder lines connecting the smaller towns.

Moreover, the endorsation of the hydro idea makes certain the construction of the proposed power plant at Niagara Falls. This will involve the early expenditure of $10,000,000. Another $5,000,000 or $6,000,000 will be added soon after the expenditure of the first ten millions, and eventually, including all expenditures, a 600,000 h.p. plant at the Falls will cost approximately $35,000,000.

At 6 per cent. interest, 5 per cent. depreciation, and 2 per cent. operating and maintenance cost (which figures are undoubtedly more than liberal), the annual charges on the $35,000,000 plant would be $4,550,000. But it would require fully $24,000,000 annual expenditure to produce that amount of power with the most modern kind of a steam plant. It is evident, therefore, that the hydro-electric resources at the Falls are well worth the proposed development by the Province, as they will yield power at a cost of less than $8 per h.p. per annum, compared with fully $40 for a steam plant. And while the price of coal continuously increases, Niagara will always flow as cheaply as ever.

THE RAILROAD SITUATION.

The net earnings of the Canadian Pacific Railway in November made a new high record for that month. The total was 140 per cent. ahead of November, 1914, 30 per cent. ahead of 1913, and 100 per cent. ahead of 1909. The gross earnings were the best for any November with one exception. Next to bank clearings (which in 1915 exceeded $900,000,000, the highest on record), there are probably no more important statistics than the earnings of the Canadian Pacific and other railways. These earnings at present indicate better business conditions and heavier traffic.

Those engaged in the manufacture of railroad equipment have had comparatively few orders during the past two years. Practically no renewals of rolling stock have been made, and but little new work has been undertaken. Considerable depreciation of locomotives, cars and general equipment has gone on without replacement. This means that work is accumulating which will require years to overtake when the war is over.

At present, many of the plants making rolling stock are busy with foreign orders. The latest to be received is for 2,000 freight cars, placed by the French government with the Canadian Car and Foundry Co. for delivery as rapidly as possible. Aside from such foreign orders, there are indications that domestic orders for equipment will be placed more frequently in the near future. Only last week, for example, a substantial order for locomotives for the National Transcontinental Railway was given by the Dominion government. This was made necessary by the prospect of a great wheat traffic, estimated at approximately 100 cars a day.

As to new construction of railroad mileage, terminals, improvements, etc., its extent depends largely on money market conditions. These have improved materially during the past few months. Confidence in Canadian

securities is unusual, and the railroads should be able this year to borrow funds for necessary work. Canada sold last year no less than $235,000,000 of its securities in the various money markets, and that sum does not include the $100,000,000 raised as a war loan within our own borders. Of the total loans raised by Canadian enterprises last year, over $33,000,000 was for our railroads. The amount that will be obtained by these borrowers during 1916 probably will be considerably greater.

EDITORIAL INDEX.

The index to articles in the editorial section of *The Canadian Engineer* for the half-year ending December 31, 1915, will be printed within the next few weeks, and distributed to all subscribers as an integral part of one of our regular issues.

CREOSOTED WOOD BLOCK ON GRADES.

By Andrew F. Macallum, C.E.
City Engineer of Hamilton, Ont.

WHEN the grade of a proposed pavement exceeds 3%, the question of a suitable pavement becomes of interest. With the variability of conditions to be met with, due to our climatic changes, the limits of most paving material are soon reached, so far as the inclination of grade is concerned.

The writer inquired from twenty-four cities to ascertain the maximum grades upon which creosoted wood block had been laid, and found that one city had laid this pavement on a 7% grade, one on 6%, three on 5% and five on 3% grades. The five to seven per cent. pavements were laid under two methods, described below.

The first method used was probably originated in Hamilton, and was used on upper James Street in 1909, on a 5½% grade. Each block had a piece ½ inch in width and 1 inch in depth cut off one face, so that while the blocks were laid at right angles to the centre line of the street, there was a space of ½ inch between each row of blocks, giving a good foothold for the horse-drawn traffic. These blocks were pitch-filled, and the cross grade of the street was sufficient to drain out any water.

The same method was adopted on King Street West, in Hamilton, the same year, and both of these pavements have been very successful in meeting the conditions of heavy traffic on two of our main streets, without a cent being spent for repairs or renewals since being laid.

The special cutting of the blocks in the manner described added considerably to the cost of the pavement, and to obviate this, the ordinary rectangular block has been used, with creosoted laths ⅜″ x 2″ laid between each cross row of blocks. This is pitch-filled as in the first method, and has been just as successful. A part of John Street South and Bay Street, each having a grade of 5½%, paved in 1911, were laid in this manner, and are to-day in first-class condition and subjected to fairly heavy traffic.

On Ravenscliffe Avenue, a purely residential street, having 6% grade, blocks spaced in this manner were laid. The reason for putting such a pavement on a street like this, having very little traffic, was that the residents insisted on a creosoted wood block pavement because of its quietness, and it has fulfilled expectations.

CANADIAN HIGHWAY DEVELOPMENT; WITH NOTES REGARDING ONTARIO'S SYSTEM.*

By William A. McLean,
Chief Engineer of Highways, Province of Ontario.

ROADS in nearly all countries fall naturally into a three-fold classification. There are main roads between towns and cities; leading farm roads, radiating from market centres and shipping points; and local feeders. The natural features of any country have been very largely a controlling factor as to which of these classes of roads has received first or chief attention.

Thus, in the province of British Columbia, traversed by the Rocky Mountains, with rich resources of mine and forest, and fertile valleys, the construction of main roads connecting centres of population has been a feature of the provincial road programme, and upon which there has been a recent expenditure of about $15,000,000.

The prairie provinces of Saskatchewan, Alberta and Manitoba, principally agricultural, with very little road material, constitute an area of earth roads, in which the grader and log-drag are to the present, the principal means of improvement. Nevertheless, their expenditure on roads and bridges amounts to about $2,500,000 annually.

The province of Quebec is making a special expenditure of $15,000,000 on road improvement. A portion is being granted as aid to municipal construction; but in addition a considerable mileage of main road has been built which will provide an excellent tourist route when completed in 1916. The trunk of this main road system under the control of the province will consist of a route from the American boundary near Plattsburgh, in New York State, thence northerly to Montreal, 39 miles; a road on the north shore of the St. Lawrence easterly to Quebec city, 151 miles (in addition to 27 miles of existing toll roads); and from Quebec city south to the American border near Jackman, in Maine, 92 miles. Another "regional" road reaches from Sherbrooke to Derby Line on the American border, a distance of about 33 miles. On this system of trunk roads nearly $4,000,000 has been spent by the province. A feature of the Quebec aid to municipal construction is that, for substantial improvement, the government will provide the necessary capital, charging the municipality 2 per cent. for a term of 41 years, the government meeting the balance of interest and sinking fund. About $8,000,000 has been thus appropriated to the present time.

Prince Edward Island, the small island province in the Gulf of St. Lawrence, a fertile agricultural area, is principally concerned with earth roads, all under the the direction of a provincial department.

New Brunswick is not as yet making any large expenditure, although the beneficial influence of a provincial office is being exerted.

Nova Scotia, the most easterly province facing the Atlantic, is not in a position to make large expenditure; but the Provincial Department of Public Roads is making excellent progress with the outlay available, more especially in the improvement of earth roads, and the construction of permanent culverts and bridges. The expenditure

*Abstract from paper read December 14th, 1915, at Worcester, Mass., before the First International Road Congress. This congress was organized by the Worcester Chamber of Commerce. The registration exceeded 600, including the following Canadians: Controller Cote, Montreal; U. H. Dandurand, Montreal; J. W. Levesque, M.L.A., Montreal; G. A. McNamee, Montreal.

of that department for the year just ended will amount to about $635,000.

Southern Ontario is probably the most densely occupied portion of Canada. In an area of about 40,000 square miles there is a population of about 2,500,000, one-half of which is urban and the other half rural. In this southern and populous portion, which is chiefly agricultural, there is a municipal expenditure on roads in the open country of over $2,000,000 annually, while the province spends about $1,500,000 annually through three road departments, *viz.*:—

(1) Subsidies to leading market and main roads in Southern Ontario.

(2) Trunk colonization roads in Northern Ontario.

(3) Minor colonization roads in Northern Ontario.

No part of Canada is so favorably placed to finance the construction of main roads as are some portions of the United States—such States as Massachusetts, Connecticut, or New Jersey, which are small in area and contain numerous cities which contribute to the cost of rural roads.

Unfortunately, and unlike the United States, the system of municipal organization has been such that all cities are wholly separated from the county and township in which they lie, and have escaped taxation for roads in the open country. This is a situation which recent legislation has sought to correct; and provision is being made that all cities shall contribute to the cost of leading roads within a reasonable suburban area.

County Roads in Ontario.—Owing to the strong claims of agricultural communities, the assistance given by the Provincial Government to the better class of construction has been largely confined to the subsidizing of leading market roads in each county.

Ontario has both township and county organization. Township councils are elected annually, and the reeve of each township is, ex-officio, a member of the county council. Township councils, primarily, have control of all the roads, but a county council is authorized to take over from the townships the leading roads of the county for construction and maintenance. To this system of county roads the Provincial Government has heretofore paid one-third of construction cost only, but under legislation of the past year, will hereafter contribute 40 per cent. of the cost of construction, and 20 per cent. of the cost of maintenance. More than half of the counties are operating under this plan with good results, and to the present time, a total of over $6,000,000 has been spent on the work. It is anticipated that, under the increased subsidy, the remainder of the province will adopt county systems in a very short time.

Counties have been somewhat lethargic in adopting the plan; but, having adopted it, and having completed a reasonable mileage, the method becomes very popular. Property along the improved roads has shown decided advance in value varying with local conditions from 10 per cent. to 40 per cent.

A favorable feature of the Ontario scheme is that, by requiring counties, at the initial stage, to adopt a comprehensive plan of roads, a well connected system finally results. The work is very often, to meet local feeling, carried on in short sections, but each successive council has a permanent plan on which to work. Construction is carried on under an engineer or superintendent appointed by the county council, but all is subject to the regulation and inspection of the Provincial Department of Highways. The provincial subsidy is paid annually as the work progresses.

A county council may issue 30-year bonds to meet its own proportion of the cost, but more commonly they extend over a 20-year period. Very seldom are bonds issued for the entire expenditure of the county, but as a rule to supplement a sum raised by uniform county rate. A county system will usually include about 200 miles, or 15 per cent. of the total road mileage within the county. The completion of such a system may extend over eight or ten years, so that by levying a county rate of 1.5 mills annually on the assessment during that period, only a very small municipal debt need accrue. Largely for moderate farm traffic, the county roads are of gravel or broken stone, single track, except near cities, and cost from $2,000 to $8,000 per mile, according to local conditions and traffic.

Assuming a county system constructed in ten years at a cost of $800,000 with a county assessment of $30,000,000, the annual arrangement would be as follows:

Direct levy of 1½ mills on assessment	$45,000
Bond issue	3,000
Provincial subsidy, 40 per cent. of total	32,000
Total	$80,000

Thus, in ten years (with proper maintenance additional), the county would have an asset in road improvement of $800,000, with a bond issue of only $30,000. To the latter is commonly added the cost of heavy machinery and permanent bridges, on which the provincial subsidy of 40 per cent. is also paid.

Bond issues for county roads are met on the annuity instalment plan. The sinking fund method has been almost entirely abandoned in the province for all municipal purposes, except in the larger cities. The annuity instalment plan is cheaper than the sinking fund method, safer, more easily managed, and is distinctly in favor with financiers, municipal authorities and the public.

Main Roads in Ontario.—Under new legislation for main roads, more attention will be given to the development of certain trunk lines, for which there is a growing demand. The chief of these connects Ottawa on the east with Windsor on the west, a distance of about 500 miles. A branch, 75 miles in length, would reach to the Quebec boundary, and another would reach from Hamilton to Niagara Falls, 45 miles. This road would form an ideal trunk highway for the southern part of the province. It would link up the various systems of county roads, would pass through the most important cities, and within 12 miles on each side is about one-half the population of the province. Some portions of this road are now in fair condition, with good gravel or broken stone surface.

The most important section, about 36 miles between Toronto and Hamilton, is now being constructed in a thoroughly substantial manner, with 4 per cent. grades, 26 feet between shoulders, and an 18-foot concrete pavement. The cost of the Toronto-Hamilton section will be about $850,000 and the work is to be completed in 1916. Other portions of the highway are now under consideration, and the linking up of the entire trunk highway is, it is believed, merely a matter of reasonable growth.

The system of management provided for this class of road is somewhat unique. A main road is interpreted as one running directly between two important terminal points or cities, and therefore passing through a series of municipalities. Such series of municipalities may petition the Provincial Government for construction as a main road; and if the petition is endorsed by three-quarters of the municipalities affected, the government will make sur-

veys, prepare specifications and appoint a special board of commissioners to take charge of the construction and maintenance of the road. The cost in the engineer's report is apportioned among the municipalities benefited (the government contributing 40 per cent., but not exceeding $4,000), and the commissioners then act as a Court of Revision to hear the appeal of any parties affected as to the engineer's apportionment of the cost. The commission may confirm or revise the engineer's report, and unless a majority of the municipalities then petition against the work, the commission is authorized to proceed with construction.

The plan of having a local commission for each main road is no doubt a weakness in one respect, in that one permanent commission for the entire province would bring greater experience and knowledge to each successive work; but on the other hand, the municipalities pay the greater part of the cost; they have, and are accustomed to, good local self-government; and "taxation without representation" is a principle which it is desirable to avoid. When a series of main roads is constructed, the tendency will no doubt be to unite them for maintenance under one commission. The plan was adopted at the last session of the Legislature and its efficiency has yet to be proven.

Classification in Ontario.—It will thus be seen that, in the Province of Ontario, the three-fold classification, so desirable in road organization, is being evolved in the following manner:—

(1) Main or trunk roads to be constructed and maintained by special commissions, under the guidance of the Provincial Highway Department; the cost to be met by provincial subsidy, and direct assessment on cities and rural municipalities benefited.

(2) Leading market roads, to be under the control of county councils, subject to regulations and inspection of the provincial authorities; the cost to be met by provincial subsidy, and county levy on all assessable property within the county, including cities.

(3) Local feeders, to be under the control of township councils, and at the expense of the township.

What Will Good Roads Mean?—In Canada there are about 250,000 miles of graded roads. Road-building is a slow process, and in most countries it has taken half a century at least to provide adequate surface construction. The immediate objective in Canada should be to substantially improve about 16 per cent. of the total, or 40,000 miles, which would carry the more concentrated market or farm traffic, while about 2 per cent. additional, or 5,000 miles, should be treated in a trunk road basis. The total cost might be approximately estimated at $250,000,000, of which about $50,000,000 has been spent. The ideal of expenditure to be aimed at for this work of main road improvement (apart from small repairs and maintenance) would be about $15,000,000 annually, or $2 per capita of population.

This is a substantial programme for a population of 7,500,000 people. It indicates one reason why road-building is a slow process—because it is expensive. It means that the work must be distributed over a term of years and among various administrative organizations. But, so distributed, and looked at from the standpoint of annual ability, the undertaking becomes less difficult. The total twenty-year cost of maintaining a household does not worry the average man—if his annual income is sufficient for the annual outlay. Road-building is a continuous work; if properly carried on, is cumulative in its growth, and is a question of annual expenditure available to meet direct outlay, plus sinking fund, interest and cost of maintenance.

Canada is a country of rich and varied resources. But natural resources are of value only as they are developed. A considerable part of the cost of such development is in transportation. The lessening of the cost of transportation, is a measure of economy, of national thrift, which will produce a large return on the expenditure. On this continent, the cost of team haulage is rarely less than 25 cents per ton-mile and is sometimes twice that amount. Under the favorable conditions of good roads in Europe, the cost is reduced to between 8 and 12 cents a ton-mile.

The tonnage carried over the country roads of Canada is not readily estimated; but railway statistics show that the total amount of freight carried by the railways and originating in Canada, is about 60,000,000 tons. This, for the most part, at one or both ends of the railway journey, must pass over the wagon road. And a considerable additional amount, consumed locally, passes over the wagon road without railway transportation. The average wagon haul for farm and natural produce is estimated at between seven and eight miles. It is probably a moderate assumption for Canada that a total of not less than 100,000,000 tons passes over the roads of the country with an average haul of five miles. If, then, the premise is true that good roads would effect a saving of ten cents per ton-mile, an adequate system of improved roads would create a profit of $50,000,000 annually on the produce and merchandise now passing over them.

The time lost in travelling over bad roads is very great. It is a fair estimate that bad roads occasion a loss of a man and team for 12 working days annually to the average farm. With over 700,000 occupied farms in Canada, this wasted time and effort, if put into road construction, would substantially macadamize the leading market roads in less than ten years.

EFFECT OF CAR LINES ON REAL ESTATE VALUES.*

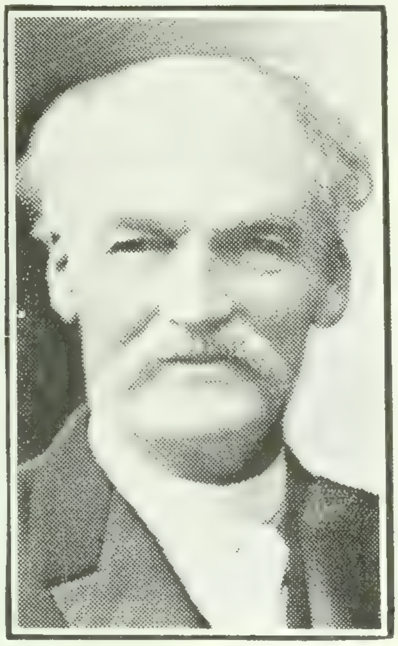
Investigation in Toronto and American cities, notably New York and Philadelphia, has demonstrated that the institution of transportation service, leads almost immediately to largely increased population in the territories served, and to largely enhanced real estate values.

Between the five years comprising 1910 to 1914, inclusive, the city of Toronto constructed approximately 18.28 miles of single track railway on Gerrard Street, Danforth and St. Clair Avenues, and Bloor Street West. An examination of the registry office records, shows that in the area within the city limits which one might reasonably estimate as being benefited by transportation, 1,525 representative property transfers, were abstracted, which show, in comparison with the sale figures of 1910, an increase of 134 per cent. in property values, integrated over the aforesaid period. During this term the average assessment per acre of the city shows an increase of approximately 66 per cent. Deducting this figure from the 134 per cent., leaves an increase in value of 68 per cent. attributable mainly to civic car line operation.

It may be argued, that the widening of Danforth and St. Clair Avenues, respectively, is responsible for a portion of this latter increment, but in compiling these figures, we have been careful to ignore transactions covering properties fronting on the aforementioned thoroughfares, the values of which, were without doubt, largely augmented by reason of the widening. If the cost of the car lines, excluding the frontage on Gerrard Street, Danforth and St. Clair Avenues, had been assessed by local improvement over the properties directly benefited thereby, the entire levy, exclusive of added charges on account of the extended life of the bonds, would have amounted to about 6 per cent. on the original investment as of 1910, or 4½ per cent. upon the increase in value during the 1910-1914 period. During the last mentioned period, the population in the districts aforementioned increased 131%.

*Excerpt from Toronto Rapid Transit Commission's report.

Canadian Engineers Honored by the King



SIR COLLINGWOOD SCHREIBER,
General Consulting Engineer to the Dominion Government.

SIR JOHN KENNEDY,
From a photo taken when he was president of Can.Soc.C.E.

SIR ALEXANDER BERTRAM,
Brigadier-General; Vice-Chairman of Imperial Munitions Board.

Three members of the Canadian Society of Civil Engineers were honored this week by the King. In the New Year's list appear the names of Sir Collingwood Schreiber, K.C.M.G.; Sir John Kennedy, K.B., and General Sir Alexander Bertram, K.B.

Sir Collingwood Schreiber was born in 1831 at Bradwell, Essex, England. He was educated in England, and came to Canada in 1852. Until 1856 he was assistant engineer of the Hamilton and Toronto Railway; 1856-1860, superintending engineer Toronto Esplanade; 1860-1864, Northern Railway of Canada; 1869, division engineer in charge of surveys, Intercolonial Railway; 1870, superintending engineer for Canadian Government on Eastern Extension Railway of New Brunswick; 1870-1873, assistant chief engineer, Intercolonial Railway; 1873-1878, chief engineer, Canadian Government Railways; 1880-1892, chief engineer, C.P.R.; 1892-1905, deputy minister of railways and canals; 1905 to date, general consulting engineer to the Canadian Government.

He is one of the charter members of the Canadian Society of Civil Engineers, and served on the council of the society during the first two years of its existence. At present he is an honorary member of the society. Although 84 years of age, he is still very active in the discharge of his duties, and a few weeks ago completed a tour of inspection which extended to the Pacific Coast.

Sir John Kennedy was born at Spencerville, Ont., in 1838. He was educated at Bytown Grammar School and McGill University. In 1871 he was division engineer on the construction of the Wellington, Grey and Bruce branch of the Great Western Railway. In 1875 he became chief engineer of the Montreal Harbor Commission, a position which he held until 1907, when he became consulting engineer. This position he now holds.

He takes a lively interest in all that concerns engineering in Canada, and rarely misses a meeting of the Canadian Society of Civil Engineers. He was one of the founders of that society, and the popularity that he still retains among its members, was early shown by his election as the fourth president of the society. He was vice-president of the society the year it was organized, and was a councillor for the three years following, until he was again elected vice-president in 1890 and 1891. In 1892 he became president, following T. C. Keefer, S. Keefer and Sir C. S. Gzowski in that position. In 1900 he was again elected councillor, and retained that position for eight years. He is the oldest living past-president of the society, and in 1907 was made one of the nine honorary members.

Sir Alexander Bertram was born at Dundas in 1853. He became a partner in the Canada Tool Works in 1886, and has ever since been connected with The John Bertram Sons Co., of Dundas. When war was declared he was acting as manager at Montreal for that concern. He has been an officer in the Canadian militia for many years. He is a noted rifle shot, and in 1909 was commander of the Bisley team. Some time ago he received the officer's decoration of the Colonial Auxiliary Forces.

When Sir Sam Hughes formed the Canadian Shell Committee, General Bertram was made chairman, and his work attracted the attention and praise of all Imperial authorities. D. A. Thomas, who was Lloyd George's commissioner to Canada, several times stated that Canada and the Empire owed General Bertram great gratitude for

his untiring work, night and day, without remuneration, in mobilizing Canada's industries for the manufacture of shells. When further shell production became a financial rather than a manufacturing problem, the Imperial Munitions Board, composed mostly of financiers, succeeded the Canadian Shell Committee, but General Bertram's services were retained as vice-chairman of the new board. He was elected a member of the Canadian Society of Civil Engineers in 1911, and has taken considerable interest in the society's meetings. His name appears on the list of contributors of papers published in the transactions of that society.

PROGRESS IN ASPHALT REFINING; WITH NOTES ON MEXICAN ASPHALTIC CRUDES.*

By Leroy M. Law,
Chief Chemist, the United States Asphalt Refining Co.

THE merits of refined asphalt roads quite naturally resolve themselves into the merits of the asphalts used in their make-up, for, in the same type of construction, the mineral aggregates, their preparation, etc., will be practically the same for all asphalts. Let us consider, then, these changes which have been brought about in petroleum asphalts that enable one to discuss roads built from these materials, not as possibilities, but in the light of actual reality.

Petroleum doubtless entered the paving industry as a "flux," or softening agency, for the solid, native bitumens, which were too hard to be used for paving purposes in the condition in which they naturally occur. These fluxes were not straight mineral oils, but the residue of by-products of oil distillation, for in those days the major products of all refineries were the burning oils, and later on, gasolines and lubricants. The fluxes were, therefore, what remained in the still after these more valuable fractions had been taken out, and, under the name of "residuum," were generally considered as containing the lubricating oils, waxes and pitch base. That they were actually refuse products, with little or no care in regard to their quality, is shown by the fact that the oils were frequently subjected to so called "cracking" processes for an increase over the normal yield of burning oils, etc., this to the detriment and injury of the residuum.

There are about six more or less well-defined oil fields in this country, and in some of them the oils vary from well to well, yet all were distilled for practically the same major products. It was, therefore, not surprising that the resulting residues were variable in character, and doubtless many times unsuited even for the purpose of fluxing the hard asphalts. Under such circumstances, however, petroleum asphalts originated.

The increasing use of the more successful native bitumens early became the stimulus for the development of the residuals so that they might be placed in competition with the asphalts, to which they heretofore had served only as adjuncts, and, to do so, it was necessary that they be brought from their more or less fluid state to consistencies suitable for paving purposes.

It was early found that distillation of the paraffine and semi-asphaltic petroleum beyond the "residuum" stage, resulted in decomposition of the pitch or asphalt residues to such extent that their usefulness as paving materials could not receive serious consideration; so other means were sought to achieve the desired end. For example, it was found by Dubbs that the addition of sulphur to the residuum, maintained at elevated temperatures, resulted in a molecular condensation, with liberation of sulphuretted hydrogen gas. The resulting artificial asphalts received the name of "Pittsburgh Flux," and proved to be interesting products.

Byerly, working about the same time, found, too, that by blowing air through the heated residuum, the oxygen performed a similar function to the sulphur in the Pittsburgh flux, and in 1893 took out a patent covering the air-blowing process. This proved a most important step in the transition of petroleum asphalt, for air blowing was cheaper than sulphur, and by regulating the duration of the "blow," asphalts varying from soft to hard consistencies could be produced.

Another step in the evolution of asphalts from petroleum was accomplished by compounding with the distillation residues such quantities of hard bitumens, like gilsonite and grahamite, as to produce materials of paving consistencies. Many of these compounds contained as much oil as hard bitumen. On account of the large percentage of the oil residuum required the original element of uncertainty still prevails in regard to the finished product. This, together with the high price of gilsonite and grahamite, and other factors, has doubtless served to greatly restrict the use of such preparations to-day.

This brings us up to about the year 1900, previous to which the oil asphalts were truly artificial materials. They were prepared at best from oils of low asphaltic contents, and their solidity and consistency were proportional to the artificial means employed in their manufacture.

Asphalts from Texas and California petroleum next deserve our attention, and it is interesting to note that, while they differed widely in characteristics, both are still in use to-day, though doubtless in modified form. The original Texas asphalts were low in susceptibility to temperature changes, but low ductility retarded their adoption by many cities which were maintaining a minimum ductility requirement of 15 or 20 centimeters in their specifications.

On the contrary, the California materials possessed practically unlimited ductility. Their advent was the turning-point in the evolution of petroleum asphalts, inasmuch as their preparation could be accomplished by a simple refinement direct to the desired consistency without any air-blowing.

Mexican petroleum entered the field of raw materials five years ago. The asphalts produced therefrom met successfully recognized paving and road oil tests, and a plentiful and uniform supply of the raw material is assured. Mexican asphalts, it is true, had appeared in the paving industry years ago, but the early examples were but the more or less solidified effusions from the real supply, which lay thousands of feet below the surface.

In 1910, therefore, the opening of several large wells on the east coast of Mexico began a new epoch in the asphalt business. Two types of Mexican petroleum constitute, in general, the supply of crude material brought to this country: a heavy oil of 10° to 12° Beaume gravity, carrying about 70 per cent. of asphalt, and a lighter one of 18° to 21° gravity, with an asphalt content of 55 to 60 per cent. These issue from wells of 3,000 to 5,000 feet

*Abstract from paper read at Worcester Convention, December 9th, 1915, and entitled "Merits of Refined Asphalt Roads."

depth, are collected in large storage tanks, or sometimes in earthen ponds or lakes, then are pumped into specially constructed tank-ships, ranging from 30,000 to 60,000 barrels in capacity, for transportation to the refineries of this country.

Both oils yield excellent paving materials; their high asphalt contents and correspondingly low percentages of light oils enable their refinement to be accomplished promptly and with a minimum risk of injuring the asphalt residues, which, in the handling of Mexican petroleums, are the major products of the refinery.

With both types of crude, furthermore, it is commercially practicable to stop the refining or reduction process at any stage of consistency between the fluidity of the natural liquid and the solidity of hardest paving cement, so as to give the engineer a material made by one simple process to the consistency he desires. By such procedure the natural fluxes are retained, and he is relieved of subsequent artificial fluxing with its attendant losses in time.

For paving cements and road binders there is apparently a preference for products of the heavier oils, doubtless on account of their greater density and lower paraffine content, but the lighter oils, however, serve as the chief source for road surfacing materials. When simply freed from moisture and sediment they serve as a cold surface dressing for macadam roads, the naturally occurring gasoline which they carry serving as a natural thinner to facilitate penetration into the road structure. Deprived of these lighter oils to greater or less extent, they serve in excellent manner for the more permanent and so-called hot surface applications.

A high asphalt content, with a corresponding reduction in the amount of burning oils, resulted in a complete change of purpose, and what was the "residuum," or residue, became the major product. This radical change in petroleum refinement has brought forth several new processes, among which may be mentioned those covered by the Dundas and the Trumbull patents. Both are of California origin, the former little used, but the latter in successful operation with both California and Mexican oils, and worthy of mention.

Its operation depends on pre-heating the oil, then pumping it to the top of heat-jacketed cylindrical towers, down the inner surface of which it is allowed to flow in a thin sheet of stream. Around a central vertical standpipe, or "off-take," are openings for the vapors or light oils to pass on their way to the condensers. These openings are protected by conical or umbrella-like shields so that they will not be clogged by the asphalt as it passes on its way to the bottom of the tower. The temperature employed and the rate of pumping determine the consistency of the asphalt.

The most generally used process, however, is that of steam distillation, which removes the lighter oils from the associated materials at temperature below their normal boiling points.

While these oils would require temperatures as high as 900° or 1,000° F. for their actual distillation, the steaming process enables them to be removed as low as 600° to 650° F., for in the best-regulated plants the asphalt in the still is never allowed to exceed such temperatures.

In the best-regulated plants recording pyrometers indicate the actual temperatures at all times, and when careful tests show that the desired consistency has been reached the charge is allowed to cool, then pumped to storage or drummed for shipment.

COAST TO COAST

Vancouver, B.C.—It is expected that work on the construction of the new grain elevator will be completed by the end of January.

Edmonton, Alta.—George Webster, contractor for the Grand Prairie branch of the Edmonton, Dunvegan and British Columbia Railway, states that the grading of the line is completed and ready for the steel.

Calgary, Alta.—All the plans, profiles and field work records of the proposed $3,000,000 Elbow River waterworks system are said to be missing from the city's vaults. These records cost about $10,000. Various theories are advanced to account for their disappearance.

Quebec, Que.—The new branch line of the Quebec Central Railway, twenty-five miles in length, extending from St. Camille, Bellechasse County, to English Lake, was officially inspected last week by Hon. A. Taschereau, Provincial Minister of Public Works.

Hamilton, Ont.—The report of City Engineer A. F. Macallum, recently submitted to the city council, shows the following amount of local works completed during the year: 4.7 miles of sewers; 5.1 miles of cement walks; 2.6 miles of curbs; 7.3 miles of asphalt pavements.

Fort William, Ont.—According to the report of City Engineer R. R. Knight, $24,198 was expended on streets and sewers in 1915, as against $42,683 in 1914. Local improvement works which were initiated last spring cost the city $39,754, and the laying of a feeder main to the west end of the city cost $57,393.

Kingston, Ont.—City Engineer R. J. McClelland reports that he carried out the following work by day labor during 1915: 2¾ miles concrete walks; ⅓ mile sewers; ½ mile concrete curb; 6 blocks asphaltic macadam pavements; macadam roadway; resurfacing of macadam roadways with Tarvia.

Toronto, Ont.—At noon on December 24th, the dredging work in the Toronto Harbor closed for the season. Work was carried on for about two weeks later than it was in 1914. During the winter season the equipment will be overhauled and all preparations made for active work early in the spring.

Welland, Ont.—Major James Sheppard, superintendent of roads for Welland County, has submitted a report to the county council which shows that approximately 41 miles of new road were constructed last year—21.39 miles by the county and 19.67 miles by the contractors. The total mileage of improved road on the county system is now about 82 miles.

New Westminster, B.C.—M. H. MacLeod of Winnipeg, general manager of the Canadian Northern Railway Company's western lines, has announced that his company will commence work early this year on the construction of a line from the north end of the New Westminster bridge over a right-of-way which it has acquired through this city to a station to be built here.

West Kildonan, Man.—According to the report of Engineer Eatwell, local improvements costing $330,529.36 have been completed during the past eighteen months, including Main Street paving, 1½ miles, $58,796.31; Main Street concrete sidewalks, 1¼ miles, $8,000; trunk sewer, 1 mile, $113,646.57; lateral sewers, 6.1 miles, $58,211.05; water mains, 7.15 miles, $79,294.74; fire hall, $7,200.

Montreal, Que.—According to a statement made by H. P. Borden, assistant to the chief engineer, work on

the Quebec bridge, which was started eight years ago, will be completed by next December. It is expected that by October next the great suspended span, which is 640 feet long, and weighs 6,000 tons, will be floated to its place. When finished, the bridge will have cost about $17,000,000.

Hespeler, Ont.—Work was completed last week on the installation of the waterworks system, the contract for which was awarded last June to John Hartnett, of Toronto. The reservoir has a capacity of 200,000 gallons, and is fed from two artesian wells. The standpipe, supplied by the Pittsburgh and Des Moines Steel Co., Pittsburgh, Pa., has a capacity of 100,000 gallons, and gives a working capacity of from 20 to 100 pounds pressure.

Winnipeg, Man.—Mr. J. D. McArthur, of Winnipeg, who is building the Hudson Bay Railway from Le Pas to Port Nelson for the Dominion Government, states that the line is now graded within forty miles of Port Nelson, and that steel is laid to Manitou Rapids, 190 miles from the terminus. Work has started on the erection of the steel bridge and will be completed in the spring. It is expected that the road will be finished to the Bay by next fall.

Toronto, Ont.—The recommendation of Parks Commissioner Chambers that the Humber Valley boulevard be constructed on the high land east of the river, rather than in the river valley, has been adopted by the parks committee. The agreement between Home Smith and the city in connection with the Humber Valley improvement scheme provides that the city spend $25,000 a year for six years. To date the city is about $14,000 behind in the amount that it should have expended, and Mr. Smith has urged that some definite action be taken towards completing the proposed roadway.

Point Grey, B.C.—According to a report issued by Municipal Engineer Greig for the year ended December 15th, 1915, much important work has been accomplished, including the grading and paving of the University Avenue division, the paving of Yew Street from Forty-ninth Avenue, and the completion of the portions of Oak Street, which were commenced in 1913. The report shows the total mileage of permanent street pavement in the municipality as 17.11 miles; total miles of streets rocked, 50.32; roads graded, regraded and contoured, 69.72, 4.22 miles of which were done last year; roads cleared, 55.66; lanes cleared, 43.88; cement concrete sidewalks, 29; sewers constructed, 53.50 miles; sewer connections made, 14.493; storm water drains laid, 10.74; and water mains laid, 106.116. During the year, 1.69 miles of sidewalks were laid; 96 miles of permanent street pavements laid; .57 miles of streets rocked; .66 of roads cleared, and 1.7 miles of water mains laid.

PERSONAL.

HARRY McAVOY has been elected a member of the Hydro-Electric Commission of St. Catharines, Ont.

P. A. McDONALD, of Winnipeg, has been appointed Public Utilities Commissioner for Manitoba, succeeding H. A. Robson, who has resigned.

RUFUS H. MARTIN, of New Glasgow, N.S., has been appointed assistant district superintendent of the eastern division of the Intercolonial Railway.

ROBERT GEORGE KYD, town engineer of Dunnville, Ont., has been elected an associate member of the Institution of Civil Engineers of Great Britain.

FRANK E. WATKINS, formerly associated with the Canadian Fairbanks-Morse Co., Limited, Toronto, has been appointed works manager of the East Jersey Pipe Corporation, Paterson, N.J.

FRANK P. JONES, general manager of the Canada Cement Co., and who formerly occupied a similar position with the Dominion Steel Corporation, has again joined the steel company in the capacity of a director.

GEORGE S. MICHEL, formerly assistant director of Public Works of the Province of Quebec, has been appointed engineer and director of public works by the Quebec Government, to succeed E. Charest, who has retired.

G. W. CAYE, assistant to Morley Donaldson, vice-president and general manager of the Grand Trunk Pacific, has been appointed purchasing agent of the Grand Trunk System, with headquarters at Montreal, succeeding J. G. Guess, who has resigned.

Lieut. RALPH HARRIS, formerly of the Toronto Roadways Department, and a graduate of the School of Practical Science, Toronto, has been wounded and is now in a Boulogne hospital. Lieut. Harris enlisted in the Corps of Guides, and later joined the Canadian Artillery. In England he was transferred to the Royal Engineers.

COMING MEETINGS.

AMERICAN FORESTRY ASSOCIATION. — Annual meeting to be held at Boston, Mass., January 17th and 18th, 1916. Secretary, P. S. Ridsdale, Washington, D.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Fourteenth annual convention to be held at Toronto January 18th to 20th, 1916. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

AMERICAN WOOD PRESERVERS' ASSOCIATION.—The Twelfth Annual Convention to be held in Chicago, January 18, 19 and 20, 1916. Chas. C. Schnatterbeck, chairman, Committee on Publicity and Promotion, American Wood Preservers' Association, Baltimore, Maryland.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—The Thirtieth Annual Meeting to be held in Montreal, January 25, 26 and 27, 1916. Secretary, Prof. C. H. McLeod, 176 Mansfield Street, Montreal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—To be held in Chicago, Ill., February 4th, 1916. Joint dinner that evening with American Electric Railway Manufacturers' Association.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Second National conference to be held at Chicago, Ill., February 15th to 18th, 1916. Secretary of Advisory Committee, J. P. Beck, 208 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION.—Annual Convention to be held in Chicago, February 17 and 18, 1916. Secretary, E. S. Hanson, 538 S. Clark Street, Chicago, Ill.

CANADIAN LUMBERMEN'S ASSOCIATION.—At Ottawa, February 18th, 19th and 20th, 1916, annual convention. Frank Hawkins, secretary, Ottawa.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—At Sohmer Park, Montreal, March 6th to 10th, 1916. Geo. A. McNamee, secretary, New Birks Building, Montreal.

Volume 30. Toronto, January 13, 1916. Contents of this issue on page 5.

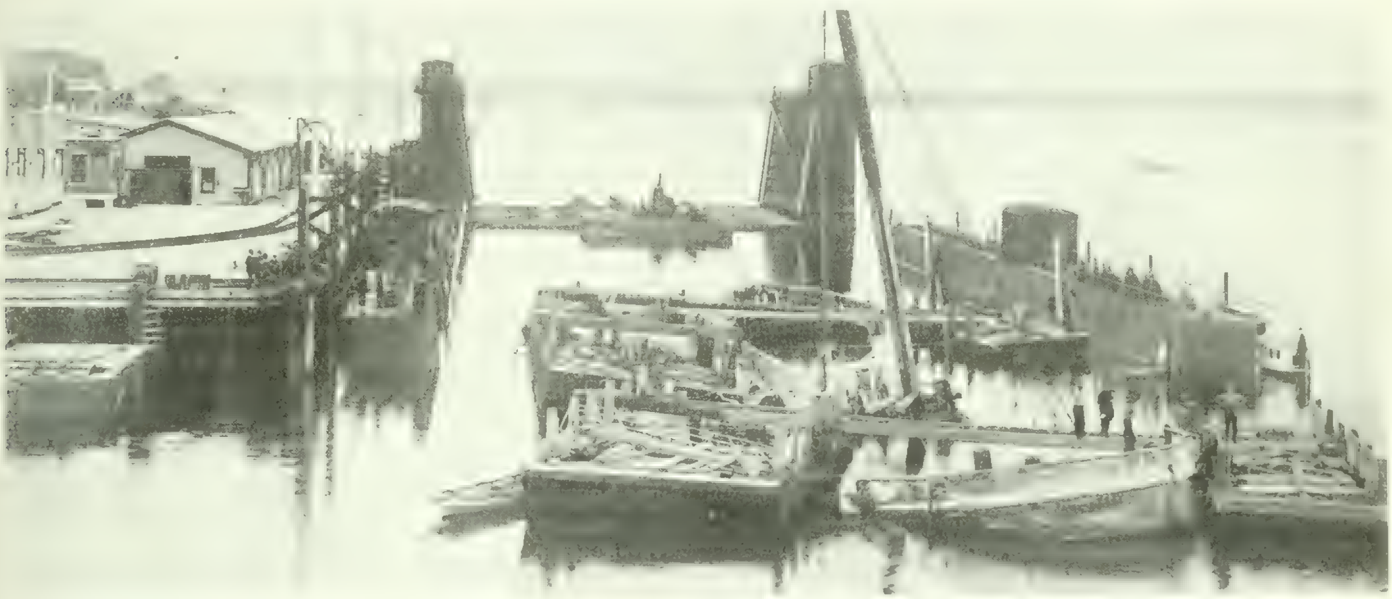
The Canadian Engineer

A weekly paper for civil engineers and contractors

G. T. P. DRY DOCK AT PRINCE RUPERT, B. C.

SPLENDID TERMINAL FOR PACIFIC COAST SHIPPING COMPLETED BY THE GRAND TRUNK PACIFIC RAILWAY, AFTER MORE THAN THREE YEARS' WORK, AT COST OF APPROXIMATELY $2,500,000.

THE largest dry dock on the Pacific Coast, either in the United States or Canada, and one of the largest of its kind anywhere in Canada, is the Grand Trunk Pacific dock at Prince Rupert, B.C. The land and wharf area is about seventeen acres. Preparation of the site included 96,000 cubic yards of dredging; 82,000 cubic yards of gravel fill; 268,000 lineal feet of piling for the wharf, and 5,000 cubic yards of concrete work for foundations, this being exclusive of any work in connection with the power house.



Middle Section (only) of Dock Submerged. Wrecked Vessel "Delhi" Being Lightered onto Submerged Section. One End Section, Not Submerged, in Background.

The Floating Dock.—The dock itself is built in three separate but interchangeable sections, the total length when joined together being 600 ft. When used separately, the two end sections are 165 ft. long, and the middle section 270 ft. long. The lifting capacity with the three sections joined is approximately 20,000 tons. The end sections have each a lifting capacity of 5,000 tons, and the middle section of 10,000 tons. The clear width between walls is 100 ft.; the over-all width, 130 ft.

The complete dock consists of twelve pontoons, each 44 ft. wide x 135 ft. long x 15 ft. deep, with a crown of 3 inches at the centre, and having 15 trusses spaced on 3-foot centres. Each pontoon weighs 490 tons, and has a lifting capacity of approximately 1,700 tons. A water-tight bulkhead, 12 inches thick, runs below the keel blocks of each section, and partial bulkheads on each side are used to strengthen the structure. The pontoons are connected together by steel side walls, or wings, which are 38 ft. high, 15 ft. wide at the bottom, and 10 ft. at top, and which contain altogether 2,400 tons of steel, and required 13,000 gallons of paint. The two end sections have three pontoons each; the middle section six pontoons. The pontoons are built of Douglas fir, protected against marine insects, first by a coating of tar and gravel, poisoned with arsenic, then by two layers of hair felt similarly treated, and covered with galvanized iron and an outside layer of 1½-inch creosoted lumber, secured with galvanized nails. The pontoons were caulked with 800,000 white pine wedges and contained 4,000,000 ft. of lumber and 400 tons of galvanized iron fastenings.

The dock, as a whole, is secured to the pier by the engagement of clamps on the dock with a vertical truss secured to the pile platform in such a way that it is free to rise and fall with the tide (which in the spring is often 25 ft.), and when being raised or lowered with a vessel aboard.

When it is desired to use the dock in separate sections, the forward three pontoons can be detached and

moved around the corner of the pier and located alongside the platform. To use the remaining portion as two separate docks, the middle section of six pontoons is detached from the rear section and moved forward the length of the front section, and secured in position. The sliding clamps are so arranged that whether the dock is used as separate units or complete, the attachments on the pier will coincide with those on the floating dock.

The Pumping Equipment. The floating dock is equipped with twenty-four 12-inch centrifugal pumps, one in each end of each pontoon. Each pump has a capacity of 5,000 gallons per minute. The entire dock can be raised or lowered 30 ft., the time required to dewater it being about 90 minutes. The pumps are connected by vertical shafts and bevel gears to a horizontal line shaft, which is operated by four 100-h.p. and two 200-h.p. variable speed A.C. motors. The motors are placed in motor houses, of which there are two on each section of the dock. The motor houses of each section also contain the control apparatus for the motors. This control apparatus is so arranged that each section of the dock can be raised or lowered from either motor house on the section, or the whole dock, with the sections joined together, can be raised or lowered from the motor house on the wharf side of the middle section. Control wires run from one section of the dock to the other, connection being made by means of plugs and sockets. In each cabin there is a master panel, on which are mounted ten knife switches, one motor master switch for each of the six motors, and four speed master switches controlling the speed of all motors.

S.S. "City of Seattle" in G.T.P. Dry Dock, November 16, 1915.

The control system is arranged so that the two motors on any section may be operated from one master panel on either of the two sections, or all six motors on all three sections may be operated from the master panel on the middle or large section. All the motors in operation will run at the same speed, and should a higher or lower speed switch be closed, all motors will automatically take the new speed. When some of the motors are operated at any given speed, if any individual motor switch is closed, the corresponding motor will automatically start and accelerate to the speed of the motors already in operation. The entire electrical equipment was supplied by the Canadian General Electric Co. The cabins on the side of the dock nearest the wharf also each contain a Jenckes motor-driven air compressor.

The General Layout and Buildings.—The dock-yard itself contains several buildings, the principal of which are the power house, carpenter shop and ship-shed, machine shop, boiler and blacksmith shop and foundry. There is a complete water system (including fire hydrants), a sewer system and a compressed air system installed for the whole yard. Standard railway tracks run to every part and to the shops. A 20-ton locomotive crane is used for shunting and hoisting. A 50-ton pier derrick, for handling freight, is mounted on the dock, and a 10-ton steam coal hoist, equipped with clam shell and capable of transferring coal from a boat or barge or railway car at the rate of 16 tons per hour, is located near the pier derrick.

The boiler house contains six water-tube boilers, rated at 400 h.p. each and delivering steam at 175 pds.

General View of Harbor and Terminal, Showing (1) End Section of Dry Dock, (2) Middle Section, (3) End Section, (4) Pier Derrick, (7) Shipbuilding Plant, (8) Power House, (5, 6 and 9) Foundry, Blacksmith and Boiler Shop, and Machine Shop.

per square inch. They are equipped with chain grate stokers. Provision has been made for the installation at a later date of two more boilers and an economizer. The feed water is passed through two heaters by two Allis-Chalmers 4-stage turbine boiler-feed pumps.

The power house, 104 ft. x 148 ft., and the chimney, 175 ft. high x 11 ft. diameter, are built entirely of concrete. The coal used is soft coal screenings and is conveyed from outside storage bins by an electrically operated monorail crane, and deposited in hoppers in front of the boilers, from which it feeds by gravity to the chain grates. The ashes are deposited into self-dumping buckets, which are conveyed to a standard flat-car outside of the power house by means of the same monorail crane which handles the coal.

The high-pressure steam line contains two 12-inch headers, one located in the boiler room and one in the engine room, connected together at three points, and provided with valves placed in such positions as to enable any part of the pipe line to be made dead for repairs without in any way interfering with the operation of the plant. The whole pipe line is covered with 2½ inches of 85 per cent. magnesium pipe covering.

The engine room contains two 1,250 kv.a., 3,600 r.p.m., 2,200-volt, 3-phase, 60-cycle generators, driven by Curtis turbines. To each turbine is connected a jet condenser with motor-driven vacuum and circulating pumps. There are also three 35 kw., 3,600 r.p.m., 120-volt, d.c. exciters, driven by steam turbines operated non-condensing, and one 25 kw., 1,200 r.p.m., 125-volt, d.c. exciter, driven by a 35-h.p. induction motor.

The switchboard is of blue Vermont marble and contains twenty panels, which include the generator and exciter panels and also the panels for the feeders going to the various sub-stations in the dock yard. The power house cables are all varnished cambric, lead covered, run in conduit.

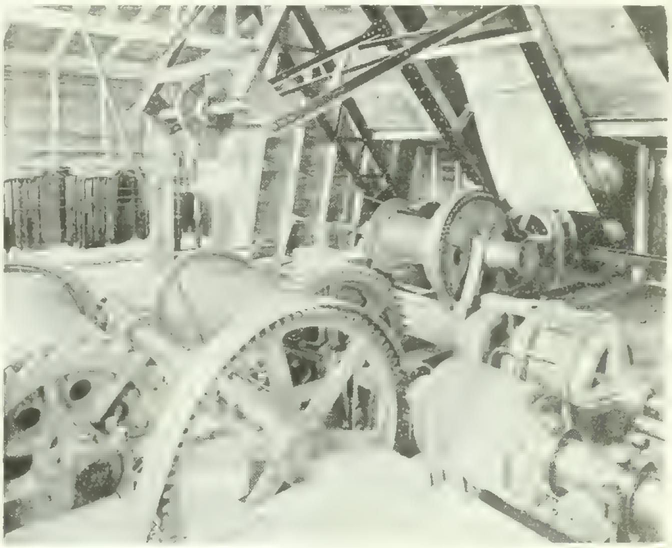
The engine room also contains a cross compound condensing air-compressor of 1,500 cubic feet per minute capacity. This supplies air to the various buildings in the dock yard. There are also two Platt Iron Works' duplex fire pumps, each with a capacity of 1,000 gallons per minute. These pumps are located in the basement and are connected to take salt water from the harbor or fresh water from the mains. They can be used as auxiliary boiler feed pumps and also to furnish water for the condensers if necessary. The engine room is equipped with a 15-ton travelling crane, which is of sufficient capacity to handle the heaviest part in the station.

The carpenter shop and ship-building shed is a steel and wood structure, 160 ft. wide, 300 ft. long and 116 ft. high, the ship-building part having an overhang of 80 ft., giving a clear space, under cover, 80 x 300 x 75 feet high. There are two 10-ton travelling cranes on this overhang, each operating over an area 40 x 300 feet. The other half of this building is used, downstairs as a carpenter shop, and upstairs as a ship hull pattern loft. The ship hull pattern loft has a floor space 80 ft. x 300 ft., entirely clear of columns or obstacles of any kind. It contains the wood-working machines, tool grinders, etc., necessary in a plant of this kind.

All the other buildings are of steel frame construction, with roof and floors of reinforced concrete. The entire equipment is of the most modern type, and the machinery installed is capable of handling the heaviest and largest repairs that may be required upon any vessel operating on the Pacific Coast.

In laying out the general plan for the present site, the possibility of future shipbuilding development was carefully considered, and, while the construction of steel vessels will not materialize for some time to come, it was nevertheless deemed advisable to construct buildings of a permanent nature. The broadside system of launching has been provided for.

The Pier Derrick.—The pier derrick stands on a piling and concrete foundation, and has a capacity of 50 tons at an outreach of 61 ft. 3 in. from the centre of the turning point, giving an outreach of 40 ft. beyond the end of the pier. The centre of the upper hoisting sheave is 100 ft. above mean high water. The derrick elevates 50 tons at a rate of 10 ft. per minute, and by changing gears, 25 tons at a rate of 25 ft. per minute. The hoisting apparatus is operated by a 52-h.p. variable speed motor, with reversing controller. The racking in and out is accomplished by a heavy steel screw, operated by a separate 52-h.p. variable speed motor, with reversing controller. There is also a 5-ton auxiliary hoist provided, operated by a 35-h.p. variable speed motor with reversing controller. The hoisting apparatus of the main derrick is 1¼-in. steel cable running through two 4-sheave blocks, each end being led to a separate drum. It is capable of removing



Interior View of 50-ton Pier Derrick.

or installing the heaviest pieces of machinery from or to the holds of any vessels in Northern Pacific waters. It is also used to transfer material from vessels lying at the dock to cars upon the pier.

Progress of Work.—Work was commenced in April, 1912, and the whole plant was started up in August, 1915, and within a few days, the wrecked vessel "Delhi" was successfully docked on the middle section. The isolated position of Prince Rupert naturally delayed the progress of the work, the nearest supply base being six hundred miles distant. To facilitate the erection of the complete plant, the structures first built were utilized in constructing the remaining buildings and docks. The first work to be completed was the pier and launching platform, followed by the erection of the power house and the installation of the necessary equipment. After the completion of the engineering and administration buildings, the final work of constructing the floating dry dock was accomplished, and the operating machinery erected.

Charles Crowell is the general manager of the dry dock. The engineers who designed the work and had charge of construction, were William T. Donnelly and Frank E. Kirby, of New York City. The resident superintending engineer was J. H. Pillsbury, of Prince Rupert.

RECENT PROGRESS AND TENDENCIES IN MUNICIPAL WATER SUPPLY.

(Concluded from last week.)

Water Disinfection. The most important single development in the art of water purification in America during the past ten years was the introduction in 1908 of water disinfection by means of calcium hypochlorite, and more recently, by liquid chlorine.

The effectiveness of calcium hypochlorite, commercially known as chloride of lime, or bleaching powder, for the sterilization of both sewage and water, has been known for many years, although its use for destroying bacteria in drinking water appears not to have been proposed until 1894 (by Traube). The possibilities of hypochlorite for the routine disinfection of water supplies were overlooked until very recently.

There are several widely known instances of the early use of hypochlorite sterilization in Europe. As an emergency measure, chloride of lime was applied at Maidstone, England, in 1897, for cleaning the water mains after a typhoid epidemic, and was temporarily used in the water supply at Lincoln, England, in 1904-05. In both these cases comparatively large quantities of bleach were used. The treatment was not considered as a routine method of purification, but for emergency use only. As early as 1903, chloride of lime was used as a disinfectant in connection with a process of chemical water purification in operation at Middelkerke, Belgium. At this same time, as part of another process, peroxide of chlorine was used in connection with other chemicals in purifying the water supply of Ostend, Belgium. During the few years immediately following disinfection of water supplies by calcium hypochlorite was introduced in several cities of Europe on a limited scale.

Disinfection by Calcium Hypochlorite.—Hypochlorite disinfection for the routine purification of public water supplies first came into use in this country in 1908. The late Dr. J. L. Leal, in June of that year, advised that hypochlorite be used to purify the water supply of the Jersey City Water Supply Co. at Boonton Reservoir. The plant for applying the disinfectant was designed by Messrs. Hering and Fuller and put in operation on September 26th, 1908, with Mr. George A. Johnson, of the same firm, in charge. In the meantime, Mr. Johnson had advised that hypochlorite sterilization be used in conjunction with mechanical filtration at the new Bubbly Creek plant of the Union Stock Yards Co. at Chicago. Acting on this recommendation, hypochlorite disinfection was introduced here on August 2nd, 1908.

Water disinfection as practised at these two plants was soon demonstrated to be a success, although it met with some opposition at first. The process attracted wide attention and was quickly recognized by engineers and sanitarians as an economical and revolutionary means of combating water-borne disease.

The use of hypochlorite disinfection followed at a great many waterworks plants throughout the country. The process was applied not only at plants having no other means of purifying water, but came into use also as an auxiliary means of purification to further improve the effluent of filter plants drawing upon unusually polluted sources of supply. At the present time hypochlorite is in intermittent or continual use as a water disinfectant at approximately 600 municipal water supply plants in the United States. This growth has all occurred within the past six years. The beneficial effect of some of these installations on the quality of the water supply is very strikingly shown by the corresponding reductions in the typhoid fever death rates. Table II., giving the figures for eight representative cities, shows that the reduction has been as high as 72 per cent. in some cases, but all of this reduction, as elsewhere pointed out, must not be attributed to the improvement in the water supply.

Disinfection by Liquid Chlorine.—The use of chloride of lime in water disinfection is comparatively simple, and yet is open to serious objections. The variation in the amount of available chlorine in commercial chloride of lime, further complicated by the deterioration of the hypochlorite during storage, and the difficulty of thoroughly mixing with water, makes it difficult to secure solutions of uniform strength. Added to this difficulty is the fact that the degree of pollution, and of organic content of the water to be disinfected, may change rapidly, requiring constantly varying amounts of hypochlorite to properly disinfect the water.

These difficulties connected with the use of hypochlorite have been partly overcome by the substitution of liquid chlorine for hypochlorite. The use of liquid chlorine for disinfecting water appears to have been first introduced by Major C. R. Darnall in 1910. His process was based on the direct absorption of chlorine gas by the water to be purified. Other experimenters working with the same end in view adopted the use of the so-called absorption tower, whereby the chlorine is absorbed by a small amount of water, the latter being then introduced into the supply to be disinfected. It is this latter process which appears so far to have had the wider application.

Liquid chlorine is now used notably at Montreal, Canada, at the Niagara Falls plant of the Western New York Water Co., at Wilmington, Del., at four filter plants at Philadelphia, including the Torresdale plant, Ridgewood Reservoir, Brooklyn, and at Wilmington, N.C., in addition to various more recent installations.

Some of the advantages of the use of liquid chlorine in place of the old hypochlorite process are that an overdose, considerably greater than necessary to sterilize the water, does not result in an objectionable taste, and that the quantity of disinfectant can be much more closely regulated than with solutions of hypochlorite, while the germicidal action is probably superior. There are other advantages due to the less space required for the liquid chlorine plant, and the freedom from objectionable taste and odor about the plant, except during accident. The use of the liquid chlorine process probably requires more skilled attendance, but through saving in labor appears not to be more expensive than the older process.

The very wide use of water disinfection, often under competent technical supervision, has contributed largely to the rapid development of the art. We are now in an excellent position to draw conclusions as to the limitations of disinfection as a means of water purification.

The great improvement brought about by disinfection in many of our municipal water supplies is remarkably shown by the diminished typhoid death rates in certain of these cities. However, it is well known by those familiar with the subject, that water disinfection even more than water filtration is dependent for safe results to a considerable degree upon human vigilance, and to be satisfactory must be in expert hands, and that even then, the process has distinct limitations as a means of water purification.

The early claims made for disinfection have been remarkably well sustained by the great success of this new process, but it is to be pointed out that disinfection is in no way a substitute for filtration where both turbidity and bacterial problems are to be met and overcome. The proper function of water sterilization is conceded to be

Table II.—Decline in Typhoid Fever Death Rate in Eight Cities Following the Use of Hypochlorite Disinfection of the Water Supply.

City.	Began Using Hypo.	Before Using Hypo. Period.	Before Using Hypo. Death Rate.*	After Using Hypo. Period.	After Using Hypo. Death Rate.*	Reduction in Death Rate.
Baltimore	June, 1911	1900-10	35.2	1912-13	22.8	35%
Cleveland	Sept., 1911	1900-10	35.5	1912-13	10.0	72%
Des Moines	Dec., 1910	1905-10	22.7	1911-13	13.4	41%
Erie	March, 1911	1900-10	38.7	1912-13	13.5	65%
Evanston	Dec., 1911	1907-10	26.0	1912-13	14.5	44%
Jersey City	Sept., 1908	1900-07	18.7	1909-13	9.3	50%
Kansas City	Jan., 1911	1900-10	42.5	1911-13	20.0	53%
Omaha	May, 1910	1900-09	22.5	1911-13	11.8	47%

*Death rate per 100,000.

either as an auxiliary to filtration, or as an emergency measure to render unfiltered supplies safe. Where a supply is continually bad, the tendency is to resort to filtration, and to use disinfection as an added safeguard against disease germs.

Other Methods of Water Disinfection.—None of the other known methods of water sterilization have yet been applied in this country on a commercial and practical scale, but remain largely in the experimental stage, although in Europe the ozone process has been rather extensively used, and the violet ray process has excited interest and attention both in this country and abroad.

Future of Water Disinfection.—The very remarkable development of hypochlorite water disinfection in this country, and the recent modification of the process by the introduction of liquid chlorine has put water disinfection on a sound basis. We are safe in concluding that disinfection as an auxiliary means of water purification has come to stay, even though the disinfecting agent may be changed in the future by the further perfection of processes now known or the discovery of new and better methods.

Accidents to Distribution Systems.—One of the most important requirements in distributing water for municipal supply is to give continuous service. The past ten years have afforded notable examples of serious interruptions of service. In the larger plants these interruptions have been caused usually by breakages in the water mains. Water hammer, defective pipe, settlement or disturbance of pipe or conduits by nearby construction, by flood, by fire and by earthquake, have all had a share in these accidents. Many of the breaks have been unavoidable, but from some of them valuable lessons have been drawn.

The losses sustained, as a result of these breaks, through interference with industry, suspension of fire protection, and pollution of the water supply, have been in some instances very great. Some of the worst conflagrations of the past decade followed water pipe breaks that resulted in failure of fire protection at a critical time. The importance of avoiding such losses and increasing the factor of safety in water distribution has led, in some cases, to the provision of cisterns scattered through the distribution system where there is danger of disruption of the system from any cause. The need of having duplicate supply mains or conduits and the importance of provision for promptly isolating parts of the distribution system, by hydrants always accessible, and other precautions, is perhaps much better recognized to-day than formerly.

Water Consumption.—The question of water consumption has grown to be of vital importance in many American cities. It is now quite generally recognized that the usual very high rates prevailing in our cities result from waste, and increasing attention has been paid during the past ten years to waste prevention. Energetic waste prevention has materially reduced the consumption in some cities, and others have been able to maintain rather enviable low rates of consumption. Notwithstanding this work, very high per capita consumption continues to be typical of many American municipal water supplies.

The consumption of water in this country varies from less than 40 gallons per capita in some cities to 400 gallons in others. This wide range in rate of consumption is still more striking if we compare it with the consumption in Great Britain, where the combined domestic and trade consumption is in several cases even below 25 gallons, and the highest rate only 70 gallons per capita. Even allowing for a somewhat more liberal legitimate domestic use of water in this country, and a greater consumption for industrial uses, it is difficult to reconcile the high rates so common in this country with the low per capita consumption abroad, and the lower rates of consumption in some of our own cities. A partial explanation is found in the very considerable waste of water. This waste is principally underground leakage and leakage in plumbing, as well as careless use, but may also be due to theft.

The total waste from these causes is so great that much attention has been given during the past decade to water waste prevention. This work, especially in the larger cities, has become a very important part of waterworks management, and has made possible very considerable reductions in the consumption. Greater attention has been given to metering services as a means of curtailing waste, and more attention has been given to water waste surveys. Devices for measuring flow in pipes and ingenious methods of detecting leaks have been developed that make it possible, at reasonable cost, to discover and stop large leaks in the distribution system.

Several very instructive water waste surveys have been made during the past few years that throw light on the enormous waste that occurs in some of our principal cities. In Chicago, where about 200 gallons per capita is delivered to the distribution system, it was concluded that 30% of the water entering the mains was wasted through underground leakage, and 20% by leakage in defective plumbing. In Chicago, it is stated that only 50% of the net pumpage actually reaches the consumer.

Considerable new data has been obtained in the last few years in cities where all consumers were metered, and where the station ouptput is also reliably metered. In a considerable number of these cases the proportion of water metered to the consumer to the entire output has been found to be as low as 45 to 50%. The highest percentage has not exceeded 78% to a possible 90%. This is undoubtedly an interesting field for further study.

New York, by systematic surveys and waste prevention, was able, in 1912, to reduce the total water consumption 90 million gallons per day below the estimated needs

for that year. This work has been energetically carried on to tide the city over the period until the new Catskill supply becomes available. The results have continued to be so satisfactory that the rate of consumption is now lower than for many years past, and the city is assured of a sufficient supply even though the expected time of completion of the Catskill project has been postponed one year. The New York water waste surveys have cost very much less than the estimated cost of the temporary additional supplies that would otherwise have been needed. At Washington, D.C., and other cities, work of the same kind has been carried out on a less extensive scale, but with results almost as important to the cities involved.

These water waste surveys show clearly that the figures covering what is called "consumption" may, in this country, indicate even as much as twice the amount of water actually used. They point out to the waterworks manager a very fertile field for economies that not only save money, but virtually increase the capacity of the plant. The usual great cost of supplying water and the difficulty of meeting constantly increasing demands make waste prevention of great importance, and we may expect increasing attention to be given to this aspect of the water supply problem.

The tendency is towards increased use of metering to reduce waste. But metering is often unpopular and is still opposed by the public in some of our largest cities. Especially in those localities where there is an abundant visible supply of water, the idea has prevailed that water should be "free as air," and in these cities popular prejudice against meters continues to be particularly strong.

Many of our largest cities, including New York, Chicago, Philadelphia, Buffalo and Pittsburgh, still have very small percentages of service metered or no meters at all, and, as a rule, very high rates of consumption. But the strong tendency, in spite of this local prejudice, is towards the more general use of meters, so that we may look forward to a great extension of the practice of metering services and charging for quantity of water used instead of by flat rate or frontage, regardless of actual use.

The tendency towards the increased use of meters in municipal waterworks service is shown by Table III.

Table III.—Comparison of Percentage of Metered Services at Different Periods in 82 Large American Cities.*

Per cent. services metered.	1900 No. of cities.	Total population.	1906-12† No. of cities.	Total population.
100%	1	32,700	7	960,300
75-100	13	848,700	21	2,818,900
50-75	5	500,300	12	1,004,000
25-50	15	1,221,200	14	1,718,600
10-25	9	636,300	10	2,047,100
0-10	39	11,513,500‡	18	11,569,300§
Total and averages	82	14,761,700	82	19,872,200

* These cities were all over 25,000 population in 1900.

† The data in this column was obtained for various years from 1906 to 1912, inclusive, most of it being for the years 1910, 1911, or 1912.

‡ Includes New York and one other city reported as having no meters.

§ Includes New York and six other cities reported as having no meters.

Considerable interest has been taken during the past few years in the classification of water consumption. Figures showing the domestic and trade consumption and use for other purposes are now comparatively rare, but will, without doubt, be more plentiful in the near future when their value is more generally appreciated.

Fire Protection.—Provision for fire protection continues to be a consideration of the utmost importance in municipal water supply. The severe requirements of adequate fire protection service in certain districts of our larger cities have led, during the past ten years, to the development of independent high pressure fire systems to serve those parts of the city in which the fire hazard is unusually great. These high pressure systems have their own separate pumping stations, distributing mains and hydrants, and usually a separate source of water supply, and are in addition to and entirely distinct from the ordinary waterworks system serving the same district and affording some degree of fire protection.

High pressure fire systems are, as a rule, designed to furnish pressures ranging from 200 to 300 pounds per square inch. Intermittent operation, large capacity, safety and reliability in service and the ability to respond almost instantly to demand are the governing features in the design of these high pressure systems. The pumping requirements are met by widely different equipment in the more important installations so far made, showing that practice has not become standardized. One high pressure fire service pumping station is equipped with crank-and-fly-wheel plunger type pumping engines, but, as a rule, centrifugal pumps are used for this service, either gas-driven or actuated by motors or steam turbines. The sanitary quality of water for this service is of no consequence, and the most readily available supply is used regardless of quality, even salt water being used.

The early installations of this kind were made in 1908 and 1909, New York City and Philadelphia being among the first cities to make this departure. At the present time, Baltimore, San Francisco, and Oakland, Cal., as well as Toronto and Winnipeg, Canada, have installed high pressure fire systems.

Equitable Rates, Valuation.—During the decade just past, there has been a notable movement for State and national regulation of public utilities where water supplies have been privately owned, and in some States, where they are municipally owned, this regulation has operated to control more thorough examination of the value of the property devoted to the public use, the proper return to be afforded it and the just and equitable apportionment of the income to be raised among the different classes of consumers. Nearly all of the States now have established Public Utility Commissions having more or less power to regulate rates, require uniform accounting, and value property devoted to the public use. A very few of these commissions, with restricted powers, existed prior to 1907, but the great majority of them, and notably their enlarged powers, have been created since about that date. Inasmuch as these commissions are largely new to their responsibilities and the subject of rate regulation both in the economic, financial, and legal questions raised are admittedly difficult and complicated, their proceedings are watched with interest, and the subject is now being extensively studied.

During the decade ending in 1915, the transfer of water supply utilities to municipal ownership has continued, though less rapidly than in prior years as the number of privately owned plants diminishes. Approximately fifteen million dollars in value of private utility property in water supply has become municipally owned since 1905 in the United States, and several large properties yet remaining in private hands will undoubtedly be transferred to the public control at an early day.

METHODS OF WASHING SLOW SAND FILTERS.*

By John Gaub,

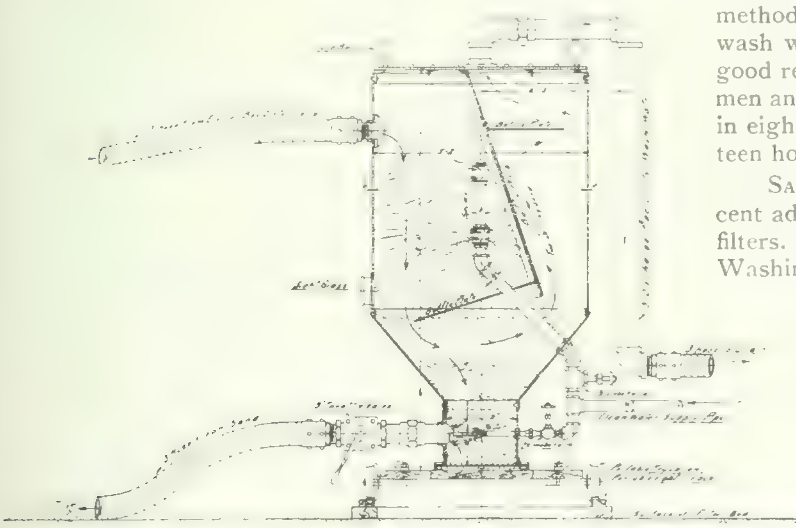
Superintendent of Filtration Plant, Washington, D.C.

IN late years various processes for cleaning the sand of a filter bed have been advanced; some partly destroying and others exterminating the filter film on the bed. These ideas have in some cases caused trouble and in others only repair. There is no doubt that the rough treatment of the sand surface, a penetration of organic matter and filth into the bed cause deep clogging, which prevents the yield of water, and causes the beds to become inefficient.

Attempts to reduce the work of cleaning filters are commendable, because scraping, sand handling and raking are the items of greatest expense in slow-sand filter maintenance; hence it is the endeavor of the writer to show what attempts along this line have been made, both from an economical and efficient standpoint.

In this country it is bad economy to discard the sand scraped from the filters, for the expense attached to the preparation of new sand is very high, since it must be washed free from clay and screened before it is ready to be placed in the filter. Yet, in Osaka, Japan, the sand is dredged from the Yodo River opposite the waterworks, and made suitable for the beds and placed therein for about 65 cents per cubic yard, a figure so low that no attempt is made to recover by washing the sand scraped from the filters.

In handling the sand for slow sand filters several methods have been tried, each giving results at a small cost in some places, while in others the contrary is true. The writer, therefore, compiled tables from plants using these methods, together with their costs. However, before delving into the methods as practised at the various plants, a brief description of the methods commonly used will not be out of place.



Portable Sand Washer Used at Toronto.

THE BROOKLYN METHOD.—This method was first used in 1905 at the Hempstead filters, at Rockville Centre, Long Island, and consists in lowering the water to a few inches in depth above the surface of the sand on the filter. Unfiltered water is taken from an adjacent filter in service and run in a stream over the bed to the outlet drain, a depth of about 1 inch of flowing water being maintained over the section to be cleaned. Men in boots agitate the surface of the sand with long-toothed garden rakes, thus stirring the dirt from the sand and having it carried away to the drain. The filter is generally cleaned in sections by cutting off the part undergoing cleaning from the rest of the filter by boards set on edge and driven down into the sand, forming a miniature flume with board sides. After cleaning, the boards are removed to a new position. When the filter is clean, filtration is resumed. This method is somewhat costly, in that about 1 per cent. of wash water is used. In cases of emergency it has given good results. At Philadelphia, it is reported that with 14 men and a foreman a three-quarter acre bed can be cleaned in eight hours and that such a bed will be out about nineteen hours a month.

Sand Washer in Use at Toronto.

SAND WASHING MACHINES.—These machines are recent additions to the washing apparatus used in slow sand filters. They began their existence about 1909, when the Washington plant adopted the "ejector washer" system. Previous to this time the dirty sand, after being scraped, was shovelled into portable ejectors on the beds, to be thence forced by water pressure through pipes to stationary sand washers. After being washed, the sand was discharged into storage bins, from which carts driven underneath may be loaded, and the sand carried to the filter and placed.

THE BLAISDELL MACHINE.—This machine may be described as a travelling crane spanning a filter unit and supporting a watertight rectangular chamber containing the machinery necessary, and provided with means for lowering this chamber to the sand surface and travelling over the filter while the process of washing is in progress. The chamber wherein the washing takes place may be raised so as to clear the rim of the filter and thereby remove the machine to another filter.

About two inches above the sand or bottom of the sand chamber there is a plate or diaphragm dividing the washing chamber into two compartments placed above each other; the lower, used as a suction chamber from which the dirty wash water is withdrawn, contains stirrer

*Abstract of paper written for the current issue of the American Waterworks Association Journal.

wheels mounted on vertical shafts; the upper contains the driving mechanism for the stirrer wheels and also the pressure and suction pumps.

From the stirrer wheels, in the lower chamber, supported on vertical shafts above the sand, numerous teeth project into the sand to any desired depth. The teeth are hollow and perforated in order to create a water jet action from the supply delivered by the pressure pump. The water for the pump is taken from the water on the filter, while at the same time a suction pump joined to the top chamber withdraws not only all the water the pressure pumps supply through the perforated teeth, but also an additional amount from the filtered water in the sand. In operation, the teeth scour the sand, while the wash water, by its jet action, drives the dirt into the suction chamber and the clear water stored in the filter bed is drawn into the washing zone by the excess suction over the pressure supply, and the wash water is pumped from the supply before the machine passes a given point. The chamber is placed close to the surface of the sand by shoes extending in advance and to the rear of the front end back plate, while the side plates cut down into the filter sand.

The pressure water rises through the disturbed sand zone and is displaced by the inrush of clear water, the upward current of which occurs well toward the centre of disturbance created by the teeth and covered by the suction chamber. The sand is forced apart by the teeth, and as they return the strong upward current of wash water causes a temporary suspension and churning action within the suction chamber. During this time the dirt and light particles are brought to the surface and withdrawn with the wash water. The sand in suspension settles after the violent upcast subsides, so that when the sand comes to rest it is uniformly water packed and free from air. The wash water from the machine is discharged to a gutter formed generally in the party wall between filter units. The wash water may be so controlled that sizing may be done by working all very fine sand to the surface and removing that which is too fine from the filter. This sizing is done by increasing the duty of the pressure and suction pumps so as to secure a downward velocity by which to hold the sand in suspension.

All of the operations of this machine are controlled by separate motors which are operated from a platform. Generally there are six motors mounted on the machine with variable speed controllers. With this machine it is possible to wash a bed of an acre in about twelve hours, and in about fifteen hours the bed can be in service, allowing three hours for closing valves, etc.

The Nichols Washer.—This machine has been in use since 1910. It enables the operator to wash the sand on the filter without removing it from the bed, thereby saving not only in wash water, but also in labor, etc.; in other words, the total saving being about 35 per cent. of what it would cost to use the old method of scraping, removing, washing and replacing the sand. Briefly, the machine consists of an inverted cylinder inside a closed jacket. The dirty sand is fed into ejectors in the usual way, and the wash water with the sand and dirt passes through the machine. The water strikes the side of the cylinder, and the sand being heavy drops to the bottom and passes through a nozzle on to the filter. About 2 per cent. of fine sand passes out with the water and dirt to the court where it generally settles while the débris goes to the sewer. It has been shown at some places that it is possible to clean 10 cubic yards per hour using 1,200 gallons of water per cubic yard, whereas by the old method 2,800 gallons of water were used. Again, at some places this machine has been modified, in that several sprays of water play on the sand within the machine; also more baffles have been added, thus causing a better wash for the sand.

Methods of Washing Sand at Various Plants.

Washington, D.C.—Until 1909 the filters were scraped and the sand piled, and then removed by ejector and one or more lengths of hose to the sand washers. After the sand was washed, it was discharged into storage bins from which carts were loaded and the sand brought to the desired place on top of the bed, and there dumped and spread evenly. After 1909 the hydraulic method of replacing was used, whereby an ejector is placed underneath the outlet gate in the storage bin, and the sand is carried in a reverse direction from the bin through piping and one or more lengths of hose to the bed. This process has decreased the cost of resanding and has proved very satisfactory in every way. This method has been used or tried in several places with more or less good results. At Washington the filters are resanded as follows: The filters are filled with water to the desired depth of the sand layer. The outlet end of the hose is joined to a 3-inch pipe supported on a boat, and the sand is discharged through the pipe at the point required. Generally work is begun at the far end of the filter, and is gradually filled by swinging the boat from side to side and backing it by degrees to the front end. By this method the sand has no tendency to separate into different sizes, if the discharge has a slope of about 40 to 45 degrees from the horizontal. By this position of the discharge pipe the old surface of the sand is cut and moved ahead with the new sand, thus breaking up the possibility of forming a mud layer between the old and new layers.

The average cost of scraping is $0.096 per cubic yard, or $0.07 per million gallons, or $16.08 per acre. The cost of raking is $0.042 per cubic yard, or $0.03 per million gallons, or $6.64 per acre. The cost of ejecting, washing and transporting is $0.168 per cubic yard, or $0.11 per million gallons, or $28.32 per acre. The cost of replacing is $0.08 per cubic yard, or $0.06 per million gallons, or about $13.10 per acre.

The movable sand ejector is novel for two reasons: (*a*) The water for making the sand into suspension is brought up from the bottom and rises as the sand is shovelled into it, thus producing a mixture having more sand in proportion to water. (*b*) The discharge ends of the ejector are made like the discharge end of a Venturi meter, with a flat batter. The economy herein lies in the fact that use is made of the velocity head in the throat, which is lost with the batter made in the usual way.

The sand washer used here differs from the usual type of washer, in that the mixed sand and water fall into the hopper. From the hopper there is a free opening to a chamber formed by a globe casting. A second jet of water enters this chamber near the bottom, and is carried into the throat of the ejector with the sand as it leaves the hopper. The sand settles through the water into the chamber and is separated from all dirty water which came with it. The hopper usually used dilutes the dirty water in the sand, but the one devised at Washington makes a complete separation.

Toronto, Ont.—Sand is washed by a portable washer. After being scraped in piles it is put into an ejector box from which it is carried to the washer. In the washer it passes through sprays of clear water, and by the action of baffles, falls to the bottom, where a strong spray drives it out through a hose, which distributes the clean sand on the filter. The wash water used is about ⅓ per cent. of the net yield of the filter. The wash water passes up to the top of the washer, then down

to a 3-inch drain which connects with a 36-inch drain. The cost per cubic yard of sand, washed and replaced, including washer pump, handling sand, repairs, etc., is about $0.61.

Denver, Col.—The sand is conveyed from the filters to the washer through an ejector and sand line of hose at a pressure of about 150 pounds. In this plant the ejector method of replacing was tried, but owing to the stratification, was abandoned. The cause of stratification probably was a too high uniformity coefficient of the sand as it left the washer. The sand is replaced from dump cars, the cars being loaded by hand, hauled to the side of the bed by horse power, dumped, reloaded into side-dump cars, pushed by hand to the place desired, dumped and spread. This is very costly, but owing to the thoroughness of mixing, it appears to be the best in the end. The total cost per cubic yard for cleaning and washing the sand on a bed is about $0.73.

New Haven, Conn.—Here the water is drawn off and the sand piled, and wheeled to the hopper and carried to the washer by hydraulic means. From the washer the sand goes to a receiver in the bed having the lowest depth of sand, in which it is spread around and allowed to accumulate until the maximum depth of 40 inches is reached, when the apparatus is put into the next bed having the least depth. By this process about 5 cubic yards per hour can be washed, using about fifteen volumes of water to one of sand. The cost of cleaning per acre is about $75, not including the cost of water. About 60 cubic yards of sand are removed per cleaning, making the cost per cubic yard about $0.43.

Lawrence, Mass.—The sand is ejected to a set of three hoppers outside the bed. The sand from the last hopper is ejected to a large box having a weir which holds back the sand and permits an overflow of waste water. The sand is then shovelled out from the box down one of the ventilation holes for distribution on the bed. The cost per cubic yard is about 25 cents. It is claimed at this plant that the wheeling of the sand to the desired place and casting insures proper mixing, while the use of water pressure causes stratification due to the uniformity coefficient of the sand.

Wilmington, Del.—At this plant a very good example of the Blaisdell machine is seen. The machine is used for raking and washing the sand on the beds. It was expected that the cost of sand washing, etc., would not be greater than $1 per million gallons. However, since the plant requires intelligent superintendence at all times, and skilled mechanics for operating the washing machine, and notwithstanding that the machine is idle about 70 per cent. of the available working time, the cost has been a little over the expected cost. The total cost per million gallons is approximately $1.23.

Conclusions.—Each method has its advantages and disadvantages. The Blaisdell machine is very economical in that the time in which a filter is out is practically at a minimum; however, the days in which the filter is operated after the wash are somewhat at a minimum also. As for total yields the process practised at Washington appears to show up better. From a standpoint of duration in days the Washington methods are the best and cheapest.

From the experiences at the various plants cited it is seen that much improvement in sand handling has been in progress, especially in building machines.

The cost of cleaning a filter by machine has not been reduced below that for cleaning and replacing sand by the improved hydraulic processes. The uniformity coefficient of the sand is an important factor to consider when hydraulic processes are used.

THE MAPPING OF CANADIAN CITIES.

By Douglas H. Nelles, D.L.S., M.Can.Soc.C.E.

(Concluded from last week.)

It will be seen from the first part of this article, which appeared in last week's issue, that in order to have a standard set of city maps with a standard degree of accuracy, and made in the most economical manner possible, there should be a special branch of a Dominion Government surveying department, organized on a strictly business basis, for the purpose of making maps of Canadian cities.

A 1/10000 Scale Map.—As mentioned in the Introduction, there should be a smaller scale map published besides the 1/1000 scale suggested. For the second set of maps a natural scale of 1/10000 is suggested. This is the scale upon which the Geodetic Survey of Canada is publishing the topographic maps of the Thirty-one-Mile Lake watershed, Quebec. It is the standard scale of the United States, Coast and Geodetic Survey for harbor surveys, etc. Their field instructions read as follows: "For all general coast topography in new regions, unless otherwise specified, a scale of 1/20000 will be used. Larger scales, such as 1/10000, and, in exceptional cases, 1/500, are to be used for special harbor surveys where the amount of detail or the importance of the locality warrants."

As before mentioned, the whole of the United Kingdom of Great Britain and Ireland is mapped upon a 1/10560 scale. The city of Cincinnati is now publishing a smaller scale of wall-map on a scale of 1/14400. The 1/10000 maps would be published in sheets, representing five minutes in latitude and five minutes in longitude, which measures, on the ground, four miles east and west and five miles 4,000 feet north and south. On paper, the topography would cover a space of 25½ inches by 36½ inches. If 144 square miles were to be taken for the proposed Federal District of Ottawa, six of these sheets would cover the district, and if mounted on linen, would make a wall-map six feet and five inches wide and six feet and one inch high.

The 1/1000 Scale Map.—The topography on the published sheets of this scale would cover as much paper as that of the 1/10000 scale, and the bounding lines would be parallels of latitude and meridians of longitude, and enclose thirty seconds of each, which would measure on the ground a space 2,100 feet wide and 3,050 feet high.

On this scale the convergence of the meridians could not be shown. The latitude and longitude lines which would form the boundaries of the topography would, therefore, be drawn at right angles to each other. The projection lines of the sheet, for the convenience of making measurements from it for engineering purposes, would be latitude and departure lines, drawn one thousand feet apart, and having for their zero some geodetic triangulation station.

This particular size sheet is chosen for two reasons: first, to cheapen the cost of publishing the 1/10000 scale maps; and secondly, to give a universal system of numbering the sheets which would be applicable anywhere in Canada. It would take just 100 sheets of the 1/1000 scale to make one sheet of the 1/10000 scale. They would, therefore, be numbered from one to a hundred, and the number of the 1/10000 scale sheet attached, as well as that of the degree sheet of the Canadian standard

topographical map on a scale of four miles to an inch. It would take 144 1/10000 scale sheets to make one degree of latitude and longitude, so that they would be numbered from one to 144, and the number of the degree sheet of the standard topographical map attached. This method of numbering maps would give a universal system, so that the number of any sheet, on any scale, any place in Canada, would always be fixed.

Mathematical Publications.—Besides publishing the map upon two scales, there would be what the writer calls "Mathematical Publications." They would be issued in pamphlet form, similar to what are called "Publications of the Dominion Observatory," in which are issued the astronomical results obtained at the Observatory, and also the results of the operations of the Geodetic Survey of Canada. Of these latter, there have been five publications issued, embracing the results of the Geodetic or Precise Levelling Division, which can be obtained by application to the superintendent of the Survey at Ottawa.

The mathematical results of a city survey would be as follows: First a list of all triangulation stations, their descriptions, elevations, latitudes, longitudes, azimuths and back azimuths, distance between stations and their logarithms, latitude and departures from the station chosen as the zero point for the co-ordinates of the map, and a map of the triangulation. Secondly, a list of all traverse stations containing their latitude and departure from a chosen triangulation station, the bearings of courses, elevations above mean sea level, and their descriptions. Thirdly, a list containing all the survey bench-marks, and also all the old city bench-marks, together with their descriptions and elevations above mean sea level.

Besides the city being supplied with the two sets of maps and the mathematical publications, they would also be given a duplicate card index system similar to the one kept by the survey.

From these published results of the traverse the distance and azimuth between any two stations in the whole district could be computed accurately. They could also be authorized by a special act of legislature to act as the bases for land surveys and be used in the description of property. In this case it would be necessary for the city to employ upon its engineering staff a Provincial Land Surveyor. In any case it is good business policy of any city to have a Provincial Land Surveyor upon its staff. A recent mayor of Ottawa some years ago stated that the city paid out more than enough money for the services of surveyors in settling infringement and other cases than would pay the salary of a permanently engaged surveyor.

A Great Saving in Cost.—It will be seen from the mathematical publications used in connection with the maps that the civil engineer will be abe to make a close calculation as to the cost of any engineering project that is put forward without being put to the trouble and expense of costly preliminary surveys.

As an example: When the Ottawa Federal Plan Commission got down to work they found it necessary to spend the sum of $7,000 in rough preliminary surveys, none of which would have been necessary if they had had to their hand the published information outlined above. Again, the city of Ottawa has spent for reports upon its water problem, since the year 1904, a sum in the close neighborhood of $120,695, according to a detailed list furnished through the city auditor. It is safe to say that half this sum could have been saved on the surveys made by the "water experts" if they had had a published topographical map of the city and surrounding district. It is also probable that a saving could have been made upon the other half by not finding it necessary to get the advice of so many experts. Many other cities are probably in much the same position as Ottawa in regard to the cost of various engineering works.

Having followed the paper through this far the reader will have arrived at the conclusion that the writer is strongly in favor of having the map-making of the Canadian cities done by the Dominion Government, in order that the whole work may be properly systematized and cost kept down to the lowest possible point. When precise surveying of any kind is undertaken the cost of instruments mounts up pretty high, a sum much higher than it would be advisable for individual cities to invest in instruments which would be used very seldom after the mapping was finished. A primary triangulation instrumental outfit for one party costs about $1,800. A geodetic level instrumental outfit for one party costs about $400, other classes of work in proportion.

Cost of City Maps.—An estimate has been made of the cost of the field work for an Ottawa city map on a 1/1000 scale as described which comes to $1.55 an acre for an average of an area embracing 144 square miles. The city of St. Louis map on a 1/2400 scale cost $11.15 an acre. The map of London, England, on a 1/1056 scale, as per illustration, cost $3.25 per acre.

METHODS OF SURVEY IN DIFFERENT CITIES.

The memorandum on the survey of London on a 1/1056 scale and the memorandum on the revision of the survey of London on a 1/2500 scale were supplied to the writer by the Director-General of the Ordnance Survey of Great Britain.

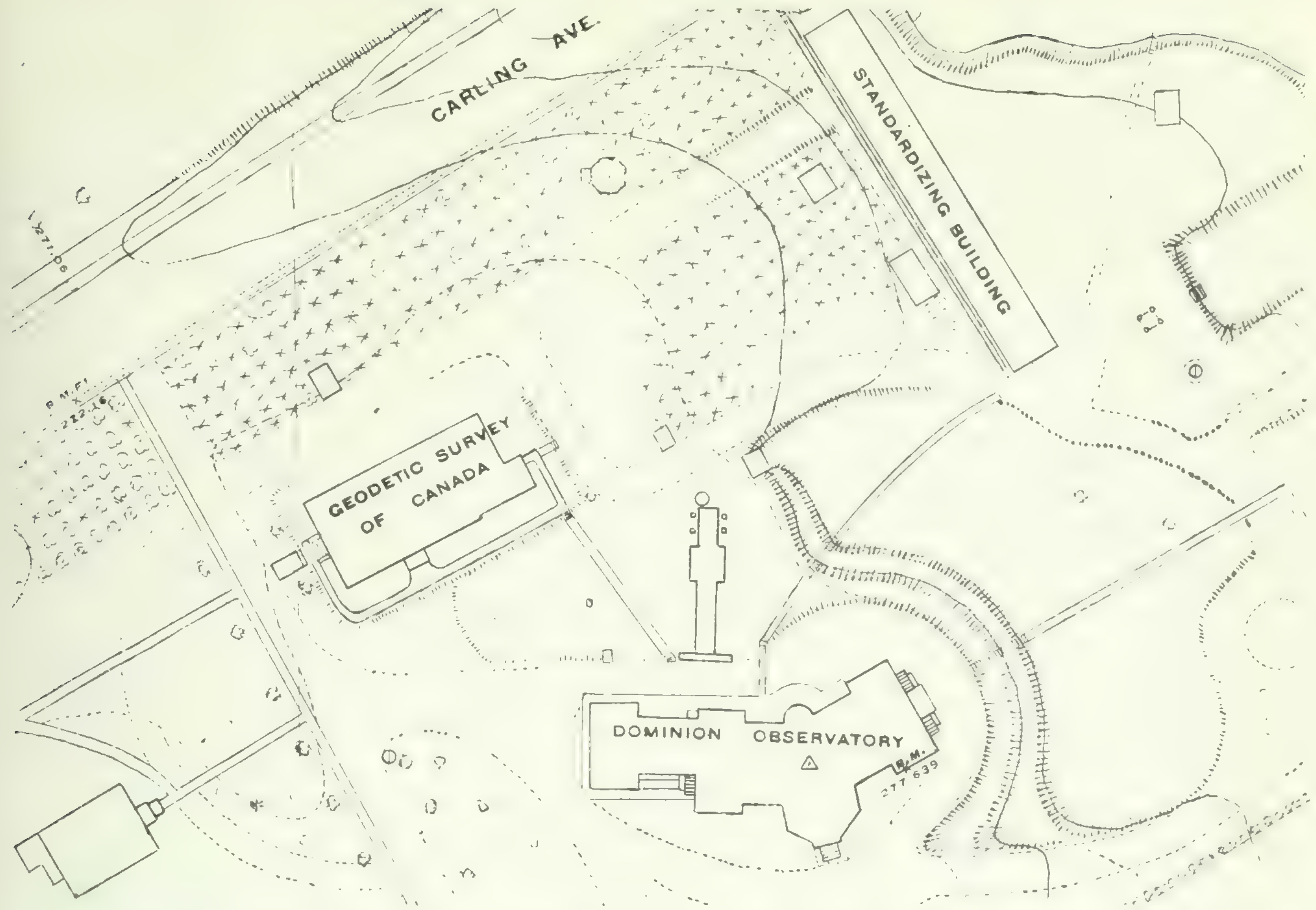
The memorandum on the Survey of St. Louis is condensed from a paper published in the transactions of the American Association of Engineering Societies January, 1893, by B. H. Colby, First Assistant Engineer in Charge of Surveys, Sewer Department, St. Louis, Mo., Member Engineers' Club, of St. Louis.

The memorandum on the Topographic Survey of Cincinnati is condensed from a paper published in the "Engineering News," April 3rd, 1913, by Hugh C. Mitchell, Engineer in Charge of Topographic Survey, Cincinnati, Ohio, formerly Assistant and Computer, United States Coast and Geodetic Survey, Washington, D.C., and also from information by Mr. W. N. Brown, of Brown & Clarkson, topographic engineers, of Washington, D.C., who had the contract from the city for the topographic part of the work, and from H. S. Morse, Engineer in Charge, Division of Sewerage, city of Cincinnati.

MEMORANDUM ON THE SURVEY OF LONDON. SCALE, 1/1056.

Trigonometrical Work.—Points on high buildings directly connected with the main triangulation of the country are fixed and permanently marked. These points are about three-quarters of a mile apart. From these points others on the ground level are fixed about one-quarter of a mile apart and are permanently marked.

These ground level points, marked by a metal bolt let into the pavement or road surface were chosen with a view to facilitate direct chain survey between points, and were fixed from the stations on the top of buildings



Portion of Specimen Sheet of Proposed Canadian City Map. Scale, 1/1000. Surveyed and Drawn by C. R. Westland, B.Sc., D.L.S.

by using a tall pole, 60 feet high, plumbed over the selected point.

When the original trigonometrical work was extended in 1909-10 the points fixed trigonometrically were somewhat further apart, and intermediate points at the junction of roads and other suitable places were fixed by traverse with theodolite and steel chain, the permissible error in traversing being 1/4000.

Organization.—A trigonometrical party consists of one observer and three laborers. A traverse party consists of one observer and three laborers.

Cost.—From 7½d. to 1s. 5d. per acre, dependent largely on interruptions due to traffic. A traverse party should traverse 1¼ miles per day.

Detail Survey.—This hangs on the traverse, and is carried out with a steel chain of 100 links and an offset rod of 10 links. Permissible error in chaining, 2/1000. No offset exceeds 20 links.

Organization.—A detail party consists of one superintendent, seven surveyors and eight laborers. Such a party would survey 10 acres per day.

Average Cost.—7s. per acre. Subterranean detail is not surveyed.

Examination on the Ground.—The plans having been plotted in pencil on paper (hand-made from pure rags) are traced. The traces are examined on the ground, corrected where necessary, and minor detail and names added to them.

Organization for Examination.—One superintendent, four examiners, and five tape boys. The superintendent finally examines the work already examined by the men of his party. Such a party would examine about eight acres per day.

Average Cost.—5s. per acre for field work; 1s. per acre for plotting and tracing.

Levelling.—The levelling is based on the main network of the country; 8 or 9 lineal miles of levelling for every square mile of country is given for town plans (5 or 6 km. per square km.). Bench marks are cut in the walls of the houses about 120 meters apart, and surface stations given at the junction of roads, and highest and lowest points on roads, at sudden changes of grade and at least one every 40 meters. This is probably more than is necessary.

Cost.—Cost per lineal mile depends on the density of traffic and on the weather. For London, about 21d. per mile, including levelling in the field, and calculating and plotting in the office, and all incidental and established charges, say, 6½d. per acre.

Organization.—The field levelling parties are independent of the detail surveyors and of each other, each party consists of one leveller and two assistants. They work all the year round in the field and should do nearly a kilometer a day.

Office Work.

Drawing.—The size of the plans is 36 inches by 24 inches and the scale 1/1056. The plans already plotted in pencil are corrected by the traces that have been examined on the ground, drawn in ink and the names of the streets typed.

Average Cost of Drawing and Typing is 1s. 6d. per acre, or £11 10s. per plan representing 153.6 acres.

Examination of Plan.—The plan is examined as to correctness of detail and names, etc. Average cost, £1 per plan.

Reproduction.—A zinc plate is produced from the plan by the Vandyke process. Average cost, 6s. per plan.

Printing.—The cost of printing an edition of 50 copies is £2 7s. 6d. per plan.

	Per acre.		Per plan of 153.6 acres.		
Recapitulation of costs.	s.	d.	£	s.	d.
Trigonometrical and traverse work..	1	0	7	13	0
Detail surveying	7	0	53	15	0
Plotting and tracing	1	0	7	13	0
Examination on the ground	5	0	38	8	0
Levelling		6½	4	3	0
Drawing and typing	1	6	11	10	0
Examination of plan			1	0	0
Reproduction				6	0
Printing 50 copies			2	7	6
			126	15	6

Sale price, 2s. 6d. per copy.

The cost of the survey was borne partly by H.M. treasury and partly by the Metropolitan Board of Works, who received as many impressions as they required at 1s. per sheet, when originally issued. The price of the issue now is 2s. 6d.

The ordnance survey does not revise the survey of London on this large scale but confines its revision to that on the scale of 1/2500 and smaller scales.

Revision on the 1/1056 scale of parts of London is carried out by the Land Registry Office, London, who could supply details as to their organization and the costs of keeping the 1/1056 plans up to date. Only the drawing and printing is carried out by the ordnance survey for the Land Registry Office, and the costs of these services are similar to those already detailed in connection with the original survey.

MEMORANDUM ON THE REVISION OF THE SURVEY OF LONDON. SCALE, 1/2500.

Preliminary.—Accurately drawn plans on the 1/2500 scale exist, having been reduced by photography from the 1/1056 scale revision of 1891-95 and redrawn on 1/2500 scale on hand-made paper. Size of plan, 37.00 inches by 26.34 inches.

Although drawn some eighteen years ago, these plans have retained their size within the limits that permit of of their reproduction by photography to true scale size with no greater error than 10 links in 120 chains.

A plate, true to size having been produced, an impression in blue on hand-made paper is made and retained in the drawing office to form the basis of the revised plan.

Red impressions on tracing paper are pulled at the same time. These are cut to a convenient size and revised on the ground.

Revision.—The revision cancels obsolete detail with black crosses, supplies new detail in black on the trace, and adds names of streets, etc.

The final reviser examines the revisers' work, and makes any necessary corrections in green ink.

Organization for Revision.—One superintendent, 3 revisers, and tape boys as required. The superintendent finally revises the work of the revisers.

Such a party will deal with 20 to 30 acres of town work per day, on an average in the largest cities in this country revised after an interval of about 20 years. For Canadian work, say, 40 to 60 acres.

Levelling.—Levelling is detailed in the accompanying memorandum on the survey of London.

Drawing.—On the return of the traces from the field the blue impression is drawn and typed from them.

The blue lines of the old detail that still stand good are inked over in black, new detail is transferred from the traces to the blue impressions and inked in. The obsolete detail being left in blue will not reproduce either by Vandyke process or photo-zincography. The plans are especially finely drawn with a view to photographic enlargement and publication on a 1/1250 scale as well as on 1/2500 scale.

Progress at Drawing.—Each plan represents 960 acres and in dense town work the rate of drawing is from 16 to 20 acres per man per day.

In Canadian towns, where detail is straighter and more regular than in London, greater progress could be expected.

In areas where the percentage of new buildings is great revision methods are not sufficiently accurate and survey methods, as detailed in the accompanying memorandum, are resorted to. The traverses start from, and close on trigonometrical points used on the previous survey.

MEMORANDUM ON THE SURVEY OF ST. LOUIS.

Triangulation.—The location of stations were for the most part, places owned by the city, such as public parks, school-house grounds, engine houses, police stations, waterworks, reservoirs, conduits, hospitals and cemeteries. After these, streets and alleys, and lastly, roofs of public and private buildings.

The instruments used were: Gamy 8-inch transit reading to 5 inches; Gamy 8-inch reading to 10 inches; Buff and Berger 8-inch reading to 10 inches.

The method of observing was that of repetitions, four sets of five repetitions each were taken, making 80 measures of each angle.

The average closing error was 03″.7 per triangle.

The adjustment of the system was made by least squares.

A pole painted alternately black and white was used for sighting on at first, but a 1-inch heliograph was used on the majority of stations. The average closing error of triangles in which the pole was used was 4.6 ins. and where the heliograph was used, was 2.7 ins., bringing the mean to 3.7 ins.

The number of stations was 87, making one station to 319 acres, or two stations to each square mile. There were 26 stations situated upon the roofs of buildings and two-thirds of the angles were from these roof stations.

Precise Levels.—The make of the level was Fauth & Co., with Kern rods.

The number of bench-marks was 743, an average of 12 per square mile.

The location of bench-marks was distributed over the entire city for use of all departments of municipal government and also for city surveyors. An up-to-date list is issued each year by the sewer commissioner, which any person can get. Bench-marks are located on stone or iron sills of buildings, stone bridges, culverts, city limits, triangulation stones, and some are copper bolts leaded in tile slabs, buried below frost line, and connected with the surface by tile pipes.

The length of lines up to January, 1893, was 240 miles. The average length between benches was 484 meters or 1,588 feet.

The average closing error per mile was 0.009 feet.

Topography.—The scale of the map was 1 in = 200 ft.; contour interval, 3 ft.; size of sheet, 28 x 50 ins.

Method.—The triangulation stations were used as starting points and the topography taken by transit and stadia. The direction of all lines and side shots were astronomical bearings.

Cost.—Topography, $20,503.59, $0.732 per acre; precise levels, $10,890.31, $0.277 per acre; triangulation, $4,079.43, $0.145 per acre; total cost per acre, $1.154; cost of sewers per acre, $638.

MEMORANDUM ON THE RE-SURVEY OF THE CITY OF CINCINNATI.

Triangulation.—Main stations are especially built, tripod and scaffold signals with flag pole. These rest either on the ground or on some solid building. In this city the public school buildings afforded good location for these towers. Several of the primary stations were spires, cupolas, or flag poles on prominent buildings, occupied eccentrically.

The lines of primary triangulation were 1½ to 9 miles in length, the measured base line being 1½ miles long, and in addition to this measured base the scheme was tied on to the United States C. and G. S. transcontinental triangulation net along the 39th parallel by occupying two of their stations, and using their computed length.

The intersection stations were spires and chimneys mostly, there being one of these stations to every two or three square miles.

No connections were made with city surveys, but direct connection made between triangulation stations and measured traverses by observing at least three angles to the triangulation stations from points on the traverse.

The instruments used were a 12-in. direction theodolite used in 16 positions of its circle, and a 10-in. repeating theodolite with which each angle and its explement were measured in sets of six D and six R, five sets being taken. Limit of rejection for direction instrument 5 ins. Limit of rejection for repeating theodolite 4 ins. from mean.

This primary triangulation was done according to the specifications for primary triangulation of the Coast and Geodetic Survey.

There were 17 primary, 2 secondary and 50 tertiary stations, and the average triangle closing error was 2″.61.

Traverse.—Traverse lines were run with a steel tape and transit. These traverses were from 3,000 to 5,000 feet apart and have stations every 800 feet or less along their lines.

The traverses were controlled horizontally by triangulation and vertically by precise levels. The average closing error was 0.37 feet in 1,000 feet, which is a ratio of 1 3000.

Levels.—Precise levels were run over an area of about 100 square miles and in this district 145 lineal miles were run and 217 bench-marks placed.

A Coast and Geodetic Survey precise level was used and their methods followed throughout.

The bench-marks were bronze caps, on iron pipes, set in concrete, and were placed in pairs, with the idea of always running wye levels from a pair, and thus guarding against using a bench-mark which had settled or otherwise changed.

Wye levels were run over all traverse lines and connected with P.L.B.M.'s and checked upon precise level bench-marks.

The average wye level's closing error was 0.031 feet per mile.

Topography.—The plane-table was used altogether in mapping the topography which varied from river flats to very steep hills several hundred feet in elevation.

The plane-table work always started from a traverse station and ended at a traverse station, and the line was required to close to within five feet, which is as close as can be measured on a 1/4,800 scale. Marks were always left at each plane-table station so that if the line did not close properly, each course could be checked, and the survey adjusted.

The scale of the map is one inch equals 400 feet, or a natural scale of 1/4,800. The contour interval is 5 feet, except that on slopes of less than six degrees the 2½-foot contour was put in.

It is the intention of the city to publish a reduced wall map on a scale of one inch equals 1,200 feet, or on a natural scale of 1/14,400.

Purpose of the Map.—The purpose of the topographic map is for use in both the Department of Public Service and the Park Department, for the preliminary location and estimates for sewerage, streets, viaducts and parkways.

Before the map was completed it was utilized to advantage for all those different purposes. In addition to this, a newly organized survey for a rapid transit system in the city made tracings from the sheets, so that they could proceed at once with the preliminary location and estimate.

METALS USED IN SHELL-MAKING.

The following figures, taken from "Conservation," the official organ of the Canadian Commission of Conservation, furnish a comparison between the quantities of the different metals used in the manufacture of the 22,000,000 shells, for which orders have been placed in Canada, with our production of such metals in 1913:—

Steel used, 400,000 tons. In 1913 it was estimated that the production of iron ore in Canada, 307,634 tons, did not exceed 5 per cent. of the country's requirements of iron in that year.

Zinc used, contained in brass, 11,200,000 pounds. No zinc was refined in Canada in 1913 but the exports of metallic zinc in ore shipped amounted to slightly over 7,000,000 pounds.

Copper used, 55,000,000 pounds. The total production in 1913 was about 77,000,000 pounds and all of it was exported for refining.

Lead, 101,760,000 pounds. The production in 1913 was about 37,665,000 pounds, of which over 97 per cent. was recovered as refined lead.

About 32,000 tons of steel were placed in the Quebec bridge in somewhat over six months, during 1915. The work included the erection of the falsework on the south shore, the south 515-ft. cantilever arm and main posts, part of the north anchor arm and the 580-ft. north cantilever arm. About 44,000 tons, of the total 63,000 tons of steel in the bridge, have been erected. The double pins at the joints, driven in two or three minutes each, the extreme accuracy of the shop work, the yard-assembly reaming and the excellent field appliances, including flying falsework and electrically operated travelers, all contributed to rapid work. While the record day's tonnage in 1914 was 410 for one traveler, in 1915 the figure was 670.

EXAMINATION OF BITUMINOUS ROAD MATERIALS.

THE United States Office of Public Roads has issued a bulletin, written by Prévost Hubbard and Charles S. Reeve, on methods for examination of bituminous road materials. For the purpose of examination, the bulletin says road materials may be classified as follows:—

1. Petroleums and petroleum products, including heavy distillates, malthas, residual petroleums, fluxes, oil-asphalts, and fluxed or cut-back oil-asphalts.
2. Asphalts and other solid native bitumens, and asphaltic cements produced by fluxing them.
3. Petroleum and asphalt emulsions.
4. Tars and tar products.
5. Mixtures of tar with petroleum or asphalt products.
6. Bituminous aggregates, including rock asphalts or bituminous rocks, bituminous concrete, asphalt block, and bituminous topping.

All petroleum, maltha, and solid native bitumen products are subject to the following tests:—

Specific gravity.
Volatilization at 163° C.
Bitumen soluble in carbon disulphide.
Bitumen insoluble in 86° B. paraffin naphtha.
Fixed carbon.

Of these types the very fluid and sometimes the more viscous products may be subjected to the viscosity, flash, and burning-point determinations. Very viscous materials, too soft for the penetration test, are subjected to the float test, and semi-solid and solid products to the penetration test. If the material is sufficiently hard at ordinary temperatures, a melting-point determination may also prove of value. Sometimes two or more of the above-mentioned tests, depending upon the character of the material and the use to which it is to be put, may be made to advantage on a single material. When for any reason it is suspected that the material under examination has been overheated and possibly injured during process of manufacture, or prepared from a solid native indurated bitumen, the determination of bitumen insoluble in carbon tetrachloride may be made. The paraffin scale determination is made on those materials which are to be identified as being partly composed of heavy paraffin hydrocarbons. The residue obtained from the volatilization test is usually subjected to either the float or penetration test, and in addition it may be subjected to any or all of the above-described tests as occasion may require.

Tar and tar products are subjected to the following tests:—

Specific gravity.
Distillation.
Bitumen soluble in carbon disulphide.

Petroleum and asphalt emulsions are subjected to some of the methods of examination applicable to fluid and viscous residual petroleums and also to the following tests:—

Determination of water.
Determination of ammonia.
Determination of fixed alkali.
Determination of fatty and resin acids.

In addition, the viscosity test may be employed for fluid products and it is highly desirable that the float test be made on all of the viscous and semi-solid tar products. The more or less solid refined tars or tar pitches are also subjected to the melting-point determination. Mixtures of tar and petroleum or asphalt products are in addition subjected to the dimethyl sulphate test.

Some exceptional materials can not be satisfactorily examined according to any one predetermined scheme, and at the present time this matter must be left to the judgment and experience of the analyst.

Bituminous aggregates are first of all examined for the percentage of bitumen soluble in carbon disulphide. If the amount is in excess of 5 per cent., an extraction is then made on a large sample and the recovered bitumen is examined according to one of the above-mentioned schemes if it can be identified, or, if not, it is subjected to those tests which are of most value as suggested above. The extracted mineral aggregate is usually quantitatively graded and, if it is to be used or has been used as an integral part of the road proper, its percentage of voids is sometimes determined.

Special attention is called to recent modifications in the penetration test, determination of fixed carbon, and determination of paraffin scale, and to the substitution of different methods for the old distillation tests and for determination of voids in the mineral aggregate.

Penetration Test.—The object of the penetration test is to ascertain the consistency of the material under examination by determining the distance a weighted needle will penetrate into it at a given temperature. A standard needle is employed for this purpose and this needle is usually weighted with 100 grams. The depth of penetration is determined upon the bitumen maintained at 25° C., while the load is applied for five seconds. This test is made on all semi-solid and solid oil-asphalts, asphaltic cements, and native asphalts, but seldom on tar products. It is also often made on the residues of materials subjected to the volatilization tests, when sufficiently hard.

Fixed Carbon Test.—One gram of the material is placed in a platinum crucible weighing from 20 to 30 grams and having a tightly fitting cover. It is then heated for seven minutes over the full flame of a Bunsen burner. The crucible should be supported on a platinum triangle with the bottom from 6 to 8 centimeters above the top of the burner. The flame should be fully 20 centimeters high when burning freely, and the determination should be made in a place free from drafts. The upper surface of the cover should burn clear, but the under surface should remain covered with carbon, excepting in the case of some of the more fluid bitumens, when the under surface of the cover may be quite clean. The crucible is removed to a desiccator and when cool is weighed, after which the cover is removed, and the crucible is placed in an inclined position over the Bunsen burner and ignited until nothing but ash remains. Any carbon deposited on the cover is also burned off. The weight of ash remaining is deducted from the weight of the residue after the first ignition of the sample. This gives the weight of the so-called fixed or residual carbon, which is calculated on a basis of the total weight of the sample, exclusive of mineral matter. If the presence of a carbonate mineral is suspected, the percentage of mineral matter may be most accurately obtained by treating the ash with a few drops of ammonium carbonate solution, drying at 100° C., then heating for a few minutes at a full red heat, cooling and weighing.

Owing to the error introduced by the presence of considerable quantities of free carbon, reliable results cannot be obtained with tars by this test.

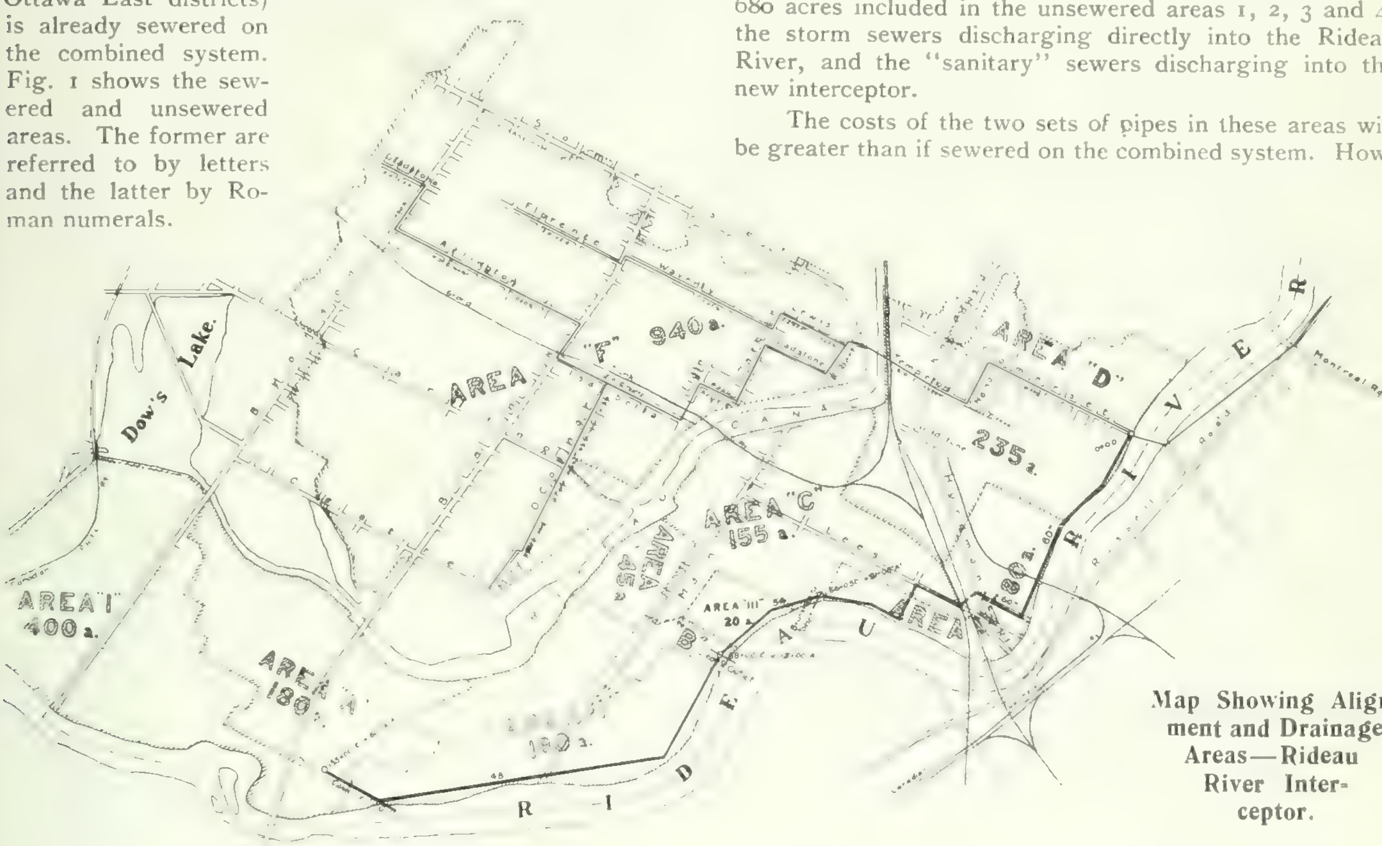
Paraffin Scale.—The method of determination of paraffin scale is fully described in the bulletin, and it is stated that the test may be made on all native bitumens and their products which are suspected of being of a paraffin nature. The authors state, however, that it is not an extremely accurate determination, and is seldom employed by the Office of Public Roads.

RIDEAU RIVER INTERCEPTING SEWER

By L. McLaren Hunter, C.E.,
City Engineer's Department, Ottawa.

In designing the Rideau River intercepting sewer, it was important to adopt such a route and grade as would permit of its convenient incorporation in the main drainage scheme which must be provided eventually for the whole city of Ottawa and its suburbs.

The new interceptor is to serve that part of the city lying between the canal and Rideau River, extending from an upstream limit along the canal, to the vicinity of Hurdman Road and Gladstone Avenue, or rather, to the boundary of the area naturally tributary to the Somerset Street main sewer. The area of this section is 1,060 acres, 36 per cent. of which (380 acres in the Ottawa South and Ottawa East districts) is already sewered on the combined system. Fig. 1 shows the sewered and unsewered areas. The former are referred to by letters and the latter by Roman numerals.



Map Showing Alignment and Drainage Areas—Rideau River Interceptor.

It will be noted that area "A" includes 180 acres in Ottawa South, with an outlet at Cameron Street. Area "B" includes 45 acres in Ottawa East, with an outlet at Clegg Street, and area "E" includes 155 acres in Ottawa East, with an outlet at Brunswick Street. The unsewered areas are as follows:—

Area "I." Including 400 acres above the Cameron Street outlet.

Area "II." Including 180 acres between the Cameron Street and Clegg Street outlets.

Area "III." Including 20 acres between the Clegg Street and Brunswick Street outlets.

Area "IV." Including 80 acres lying along the Rideau River between the Ottawa East district and the area tributary to the Somerset Street main sewer, viz., area "D."

The present main sewer has its outlet in the Ottawa River at Edwards Mill, at the foot of John Street, and crosses the canal at Templeton Street. Some of the areas tributary to this main sewer within the city are shown in Fig. 1, and are as follows:—

Area "D," including 235 acres between the canal and the Rideau River.

Area "F," including 940 acres west of the canal.

Area "E" (not shown on plan), including 290 acres in Rideau Ward.

The greater portion of these areas is already sewered on the combined system and the remainder in all probability will be completed on the same system.

The controlling features in the design of the interceptor were:—

(1) The standard of cleanliness necessary with respect to the Rideau River.

(2) The system to be adopted for the 680 acres of unsewered territory tributary to this interceptor.

In order to keep the Rideau River clean in its course through the city, the discharge of domestic sewerage into this section of the river has to be practically eliminated, and it is imperative to adopt the separate system for the 680 acres included in the unsewered areas 1, 2, 3 and 4, the storm sewers discharging directly into the Rideau River, and the "sanitary" sewers discharging into the new interceptor.

The costs of the two sets of pipes in these areas will be greater than if sewered on the combined system. However, the immediate cost of the interceptor would be very much greater if the separate system were not adopted.

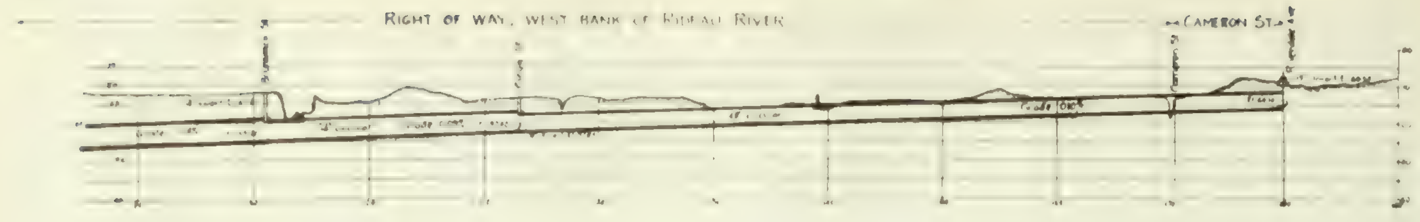
Another factor in the recommendation of the separate system is the upstream area "1," which is so low that it would cost too much to drain by gravity.

A relief sewer must also be built, to take care of the 940 acres west of the canal in area "F", as the Somerset Street main is not large enough to carry the maximum discharge which will eventually take place.

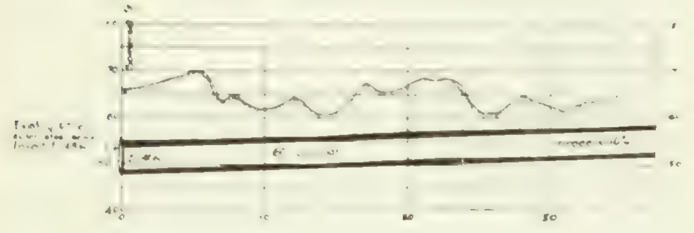
The proposed route for the interceptor is as follows:—

Along the low side of the territory, following more or less closely to the west bank of the Rideau River, until it nears the railways at Hurdman Road, where it turns northwards on to Lees Avenue, along Lees Avenue under the railway tracks to Robinson Avenue, until it reaches the Rideau River again. Then it follows the west bank of the Rideau until it flows into the main sewer on Somerset Street.

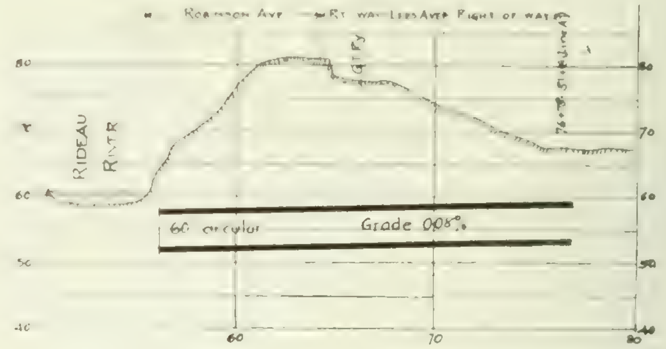
In conjunction with the new Rideau River interceptor, the city council has decided to open up a street along the



Section, West Bank of Rideau River.



Robinson and Lees Avenue Section.



LONGITUDINAL SECTIONS OF RIDEAU RIVER INTERCEPTING SEWER

banks of the Rideau River and to have expropriated, where necessary, land to a width of 66 ft. In the near future it is proposed to construct a driveway connecting Bank Street, Ottawa South, with the present driveway system in Strathcona Park, at Somerset Street. A subway will have to be constructed at Lees Avenue to connect with Robinson Avenue.

The 60-inch section of the interceptor will be built of segmental blocks; the 54-inch unit and 48-inch sections, of concrete and brick.

The estimated cost of constructing the interceptor is $315,000. The work will be done by day labor under the supervision of F. C. Askwith, acting city engineer, and W. F. M. Bryce, assistant engineer of sewers. Tenders have already been called for the supply of segmental blocks and necessary equipment.

The writer is indebted for most of the above information to Messrs. R. S. and W. S. Lea, consulting engineers, Montreal, who made the report to the city on the necessity for, and the design of, the interceptor.

ENGINEERS RECOMMEND CHANGE IN DESIGN OF WINNIPEG AQUEDUCT.

Jas. H. Fuertes and W. G. Chace, respectively consulting engineer and chief engineer of the Greater Winnipeg Water District, have recommended the construction of a 5½-ft. reinforced concrete pipe line from Deacon to the Red River, to take the place of the 5-ft. steel pipe line provided for in the original Shoal Lake scheme. The commissioners have tabled the recommendations for a month, largely in order to find out whether the change is approved of by Frederic P. Stearns and Rudolph Hering, the consulting engineers who, together with Mr. Fuertes, originally designed the entire project. In their report to the commission, Messrs. Fuertes and Chace say:—

"The site finally chosen for the location of the Transcona reservoir site and the final alignment of the aqueduct, as well as other circumstances, have altered both the hydraulic features of the problem and the costs of construction and operation, and careful studies now show that it would be more advantageous to the district and to the city of Winnipeg, from the financial as well as operation standpoint, to provide a reinforced concrete pressure pipe line instead of a 5-ft. steel pipe, from Deacon to the Red River.

"The concrete pipe should be of sufficient strength to deliver the water to the Red River, crossing under the head due to the Deacon reservoir, and having a capacity equal to the maximum daily rate of water consumption. Booster pumps installed at the Red River crossing would send the water along to the McPhillips Street reservoirs, when the consumption shall have reached the quantity which would flow to the McPhillips reservoirs by gravity from Deacon.

"One pipe line, 7 ft. in diameter, could be built at once instead of the 5-ft. 6-in. line, to be duplicated later, the 7-ft. pipe having sufficient capacity to serve until the ultimate safe capacity of the aqueduct between Deacon and Shoal Lake shall have been reached. This plan would cost about $500,000, more at the start than the single 5-ft. 6-in. line, but, in the end would cost somewhat less for construction than the two 5-ft. 6-in. lines. When the investment is considered in connection with interest, depreciation, and pumping costs, the single 7-ft. line appears to possess no merit sufficiently substantial to offset the great advantage accruing from the possession of two independent lines for the delivery of water from Deacon to the heart of the district when the population to be served shall have reached about 400,000 people.

"The cost of the pipe line from Deacon reservoir site to the Red River, differs but slightly in unit price per foot from the consulting engineer's report for a 5-ft. steel pipe line, being about $21.60 as against 20.74. The greater diameter is required on account of greater length, and will deliver to the centre of population, one-half of the entire delivery to Deacon of the aqueduct now under construction.

"Moreover—and this is important to note—this will not be a force main, but will operate under the gravity head available, whereas the steel pipe first proposed was a force main and required for its capacity the installation in future of a pumping station at Deacon. The necessity for such a pumping station is now forever removed."

Editorial

TRANSPORTATION COMMISSION FOR TORONTO.

The Toronto city council will discuss at an early meeting the report on semi-rapid transit presented by the commissioner of works of the city, the chief engineer of the Ontario Hydro-Electric Power Commission and the chief engineer of the Harbor Commission. A transportation commission, composed of business men who will serve without remuneration, will be appointed to prepare for the taking over of the Toronto Street Railway System at the expiration of the company's franchise in 1921. Such a commission will have a vast amount of preliminary work of organization to do, and it is not too early to appoint it, if the city has really decided definitely not to renew the franchise.

If the T.S.R. system is to become a publicly owned enterprise, all of the present civic lines and all civic lines built between now and 1921, should be arranged so as to be readily unified with the T.S.R. system. The projected hydro-radials should also form an integral part of the whole scheme, and all interests must be co-ordinated and must work in harmony if efficiency is to result.

The water front property controlled by the Harbor Commission will be used to a great extent, so the harbor board should have a member on the new commission. Hydro power will be needed, and interchange of traffic with the hydro radials will be most desirable, so "the Hydro" should be represented on the transportation board.

The city, of course, has the largest interest in the project, and should hold control in the membership of the new commission. The commission should be aided by, and all detailed work done through, a board of engineers. These engineers will really need the four or five years' time that they will have, in order properly to accomplish their work. Careful appraisals of all physical property owned by the private system must be made. Contracts must be arranged for supply of power, and the power actually made available for instant use upon taking over the railway. The street car men's union must be met and a scale of wages arranged and accepted by both sides. The entire clerical and operating staff must be made ready to step into their new positions at the stroke of the clock which marks the beginning of the altered ownership. Financial arrangements must be perfected, and the necessary actual cash secured. Contracts for supplies of all kinds will need attention. In other words, it is not the task of a month or even of a year, to take over as a going concern—and to keep it going—a street railway which operates over 125 miles of track, employs more than 2,200 men, and has a stock and bond issue of $17,139,500, according to its last published report, and assets valued at $23,731,935.

CANADIAN RESEARCH BUREAU.

Canadian universities are co-operating in the establishment of a bureau of scientific and industrial research. The attainment of national efficiency and commercial independence is possible only through such an established research bureau. The need for Canadian research is great, for the treasures that are hidden in the rocks and forests of this country, waiting to be utilized, are unlimited.

It is of vital importance to engineers, also, that native industries should be encouraged, and that they should be carried on scientifically and profitably. Engineering work largely depends upon research by scientists.

Many dividends have been increased and many failures avoided by the work of scientists. In fact, commercial competition demands the services of such men, and a number of American firms are spending large sums of money on research work. The General Electric Co., for example, spends over $200,000 per annum. It must not, however, be thought that no original research work has been conducted in Canada, because very important investigations have been and are being made, such as those in connection with cobalt, peat coal, fisheries, forestry, etc. Notwithstanding what has been done in this direction—principally by the Government—there is scope for enormous work of this character to be undertaken by the universities and by private enterprise.

In this connection, attention might with advantage be directed to the papers and discussions on the subject of research in chemical industry, at the New York Section of the Society of Chemical Industry, as reported in the "Metallurgical and Chemical Engineering." C. F. Burgess stated that research work pays as it pays to advertise—that there is a wide gap between factory and research laboratory when it comes to developing a process and putting it on a commercial basis, that there ought to be an intimate contact between the two departments, and that the average university graduate must give up some of his delusions, yet he must not lose his enthusiasm. President Maclaurin maintained that industries will never rise to what they ought to be until they become imbued with the spirit of the university—the scientific spirit. On the other hand, the universities will never rise to their true level until they become permeated with the spirit of industries. The function of the university is to help to organize industries on a scientific basis.

So long as we continue to draw the technical directors of our industries, the men on whom decision as to development work depends, from the purely commercial side of the organization, rather than from those men with scientific training, just so long shall we continue to cry for a more protective tariff, more favorable patent laws, etc.

The war has rendered it necessary for countries to rely more on their own resources, hence there is need for united action on the part of business men, technical men and the general public to encourage this research movement, as it tends to the conservation of our own resources.

LETTER TO THE EDITOR.

Rapid Transit for Toronto.

Sir,—The writer had been looking forward with interest to the publication of the report on radial railway entrances and rapid transit for the city of Toronto, but having read what has so far appeared, is somewhat disappointed at the conclusions reached by the engineers.

It is stated, in what may be called a preface, as follows: "The extension of adequate transportation facilities should, and usually does, precede the population, but in Toronto of late years, the conditions have been reversed."

I have yet to learn of a single city of the first class, where "adequate transportation facilities" have been provided prior to absolute necessity. Toronto is not by any means alone in this misfortune. Everywhere it is the same story of crowded and congested streets, and the incapacity to meet transit requirements. New York, though spending 300 millions on new subways and other methods of transportation, falls short of meeting the requirements of the situation, and will never probably catch up to it. The increase in population far exceeds the capacity of transportation. Philadelphia, Chicago and Boston are building subways and elevated railways and otherwise trying to catch up with belated facilities as fast as money can be provided.

Here in Montreal we have the same conditions, and our city officials look no further than they can see, and seem indifferent to the whole question, other than what is pressing at the moment.

This leads up to what I wish to say with reference to the Toronto report. The suggestions offered for increased facilities of transportation, to my mind, provide only for the immediate present. The report takes account of the radial entrance east and west into Toronto, but misses, I think, to provide real rapid transit for the city itself. The unfortunate water front is again to be utilized for additional railway traffic. Thirty years ago the writer lived in Toronto, and the old Union Station on the water front was not far distant, and easily to be reached by the entire population. A few years later, a second station was built, again on the water front, but by this time the population had expanded and it became increasingly inconvenient to reach it. Twenty-five years have passed, and a still larger and more magnificent station is to be built, and still on the water front. A map of Toronto, of the present day, has only to be glanced at to see how remotely removed this station is from the mass of the travelling public. What will be the state of things twenty-five years hence?

This is more or less aside from the question of rapid transit in the city itself, though connected with it, because the people must be brought into close communication with all these stations; and more rapidly than they are at present. Semi-rapid transit, whatever that covers, will not meet the need of the case.

The report further states: "We presume that persons who can travel from the central area to their abodes, or vice versâ, in 35 minutes, do not require more rapid transit." If this is all the rapid transit Toronto is to have, I am sorry for Toronto. A man leaving his office, say, south of King Street, should not have to spend 35 minutes on the journey home to any part of greater Toronto. The fact is, no surface transportation can give real rapid, or even semi-rapid, service. The time is coming when, as I have stated on several occasions, surface cars will be removed from the congested streets in the central areas of our large cities. Our streets are dangerously crowded with vehicles, in addition to the tram cars, and they should be free for these vehicles alone. Rapid travel to and from our homes and offices can be secured only by underground lines, with motor buses and street cars as feeders thereto.

Speeding up the service of street cars adds but little to the relief of congestion, and materially increases the dangers to the public. If it is argued, as it may be, that subway transportation will not bring adequate returns at once, it must be remembered that the municipalities have other duties to their citizens, and two of these are safety and speed in travel; for, without these, cities cannot grow.

In closing, I am constrained to say, the report as a whole is a valuable contribution to transportation literature, and interesting in its treatment of the east and west radial lines, but does not seem to offer a real solution of the rapid transportation of passengers in the city of Toronto itself.

The suggestion that a permanent commission be appointed to further investigate, construct and control all transportation improvements in the city and suburbs is an excellent one, and is in line with what I have been advocating for Montreal for several years. There must be local bodies created, jointly by the provinces and cities, with paramount authority to supervise this most important of questions—urban transportation.

F. STUART WILLIAMSON, M.Can.Soc.C.E.
(Consulting Engineer, Montreal.)

Montreal, January 4th, 1916.

ADVANCES IN SEWAGE DISPOSAL.

During recent years, marked progress in sewage disposal has been made in Canada. A recent investigation made by the Commission of Conservation revealed the following:—

In Ontario, of the total number of municipalities having sewerage systems, 37 per cent. treat their sewage; in Quebec, 12½ per cent.; in Manitoba, 33 per cent.; in Saskatchewan, 80 per cent.; in Alberta, 43 per cent.; in British Columbia, 44 per cent. The Maritime Provinces cannot be compared on the same basis, as most of the sewerage systems there discharge directly into the ocean, and treatment would be superfluous.

Conditions with regard to sewage disposal are better in the west, largely because the systems have been more recently installed, after the necessity of treatment had become apparent to all. The great majority of the systems in the eastern provinces were installed before this necessity had become so universally recognized, and, as they were not laid out for this purpose, it is in some cases costly to make the change. However, marked improvement is also to be noted, and practically all new sewerage systems either include treatment plants or are designed and installed with the view to the future installation of such plants at the minimum expense.

In the report of City Engineer A. B. Manson, of Stratford, Ont., for the year 1915, it is stated that 16,632 square yards of pavement were laid. The city placed 5,264 yards of base, and all surface, by day labor. Two miles of macadam roadways were resurfaced or repaired. Four miles of concrete sidewalks were laid by day labor. The sedimentation tanks for the sewage disposal works were placed in operation, about 350,000,000 gallons of sewage being treated annually, at a maintenance cost of $3.15 per million gallons. The cost per ton for incinerating garbage was 21 cents. Additional sanitary sewers were constructed to the extent of 1.71 miles.

LAYING SUBMERGED WATER MAINS AT VANCOUVER, B.C.*

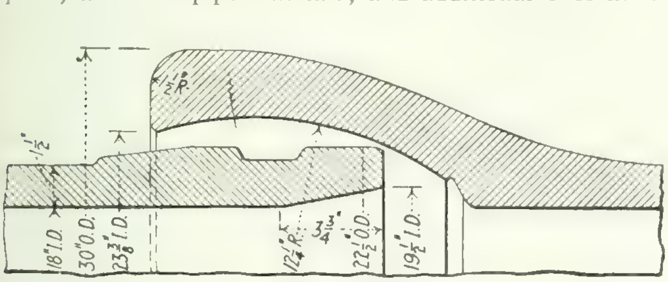
The entire water-supply for the city of Vancouver, B.C., is brought in submerged pipes across the channels connecting the city's harbor with the ocean. These pipes have been successfully laid under conditions of exceptional difficulty.

The city of Vancouver is built on a narrow peninsula between two arms of the sea. The only possible source of an adequate water supply is in the mountains which rise to a great height only a short distance north of Burrard Inlet, on the southern shores of which the city lies. As may be seen on the accompanying map, the city's water supply is taken from Capilano River and Seymour Creek. The water from the former is brought down in steel pipes to the first Narrows just below the city, and the water from Seymour Creek to the second Narrows 5 miles above.

The tidal range on this coast is from 14 to 17 ft. As Burrard Inlet has an area of several square miles and as the deep channel connecting it with the ocean is only some 900 ft. in width, a tidal current of high velocity, 8 miles an hour or more, sweeps back and forth through the channel with every rising or falling tide. Almost as rapid a tidal current exists at the second Narrows. The period of slack water in the Narrows is very short, often not more than 20 minutes. The maximum depth of water is 75 ft. at the first Narrows and 80 ft. at the second Narrows. The channel bottom is very rough and strewn with large boulders on the shore next the city; on the opposite shore is a level stretch of mud flats, bare at low tide.

Early Experience in Pipe Laying.—The first pipe laid across the Narrows from Seymour Creek was a 12-inch cast-iron pipe with Ward flexible joints. It is stated that Mr. Ward himself came to Vancouver to lay the pipe, but when he saw the swift current in which it had to be placed, he refused to attempt the job and the pipe was laid by a local contractor, who offered to do the work for a lump sum of $10,000, the city, of course, furnishing the pipe and the jointing material. He carried out his task with little difficulty and at a cost of only about a third of his contract price. Since then there has not been any difficulty in finding men to do the work.

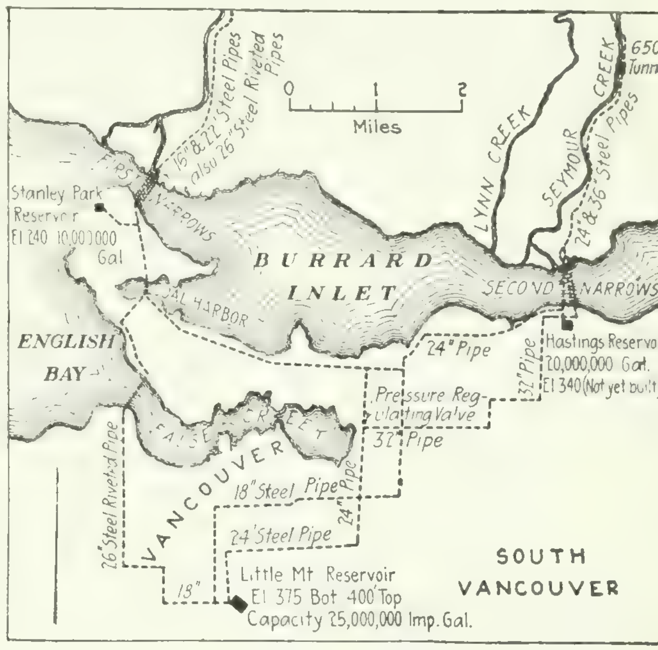
When the supply through the first pipe became inadequate, a second pipe was laid, and additional ones have



Standard Section of Flexible Joint for 18-in. Cast Iron Pipe, Vancouver Waterworks.

been added as the water consumption increased. The method of laying is substantially as follows: On the flat tidal marsh on the north shore of the river a low wooden trestle is built, extending back from the shore a distance as great as the entire width of the channel, some 1,300 ft. Upon the plank floor of this trestle the pipe is laid, and the joints are leaded and caulked. The bell of each pipe length rests on a flat wooden block free to slide on the plank floor, which is greased with tallow.

Hauling the Pipe Across the Channel.—After the pipe has been subjected to a hydrostatic test of 300 lb. per sq. in. and any leaks found have been made tight, a hauling tackle for pulling the pipe across the channel is applied. Originally a wire rope was led through the interior of the pipe and secured to the rear end of the pipe line; but the resistance of the front end as it plowed its way across the channel was so much greater than that of the rear part of



Map Showing Location of Submerged Pipe Line Crossings at Vancouver.

the line sliding on the floor of the trestle that the pipe line buckled, notwithstanding the tension on the cable inside it. The present practice, therefore, is to run a couple of hauling cables the length of the pipe line and lash them securely to it at three or four points. To the front end of the pipe line a heavy wooden prow is attached to enable it to plow its way across and take the shocks of contact with ledges and boulders.

When all is ready, a cable is carried from the end of the hauling tackle across the stream and secured to the drum of a hoisting engine on the opposite bank, and the string of pipe is thus hauled across. After the pipe is in place, connections are made at each end and the pipe is again subjected to hydrostatic test. A diver is sent down and caulks any leaks which may be found. The diver has a powerful electric light and can readily discover any leaks by the current of sand and dirt raised by the water jet issuing from the leak. The water in the Narrows is remarkably clear, there being only a trifling inflow of fresh water or sewage compared with the vast volume of fresh sea water entering at each tide.

It may be noted in this connection that the Capilano intake is 485 ft. above sea level, and the Seymour Creek lower intake is 465 ft., while "Little Mountain" reservoir, into which the conduits deliver, is 395 ft. above sea level. The maximum head of water on the submerged pipe at greatest depth is about 480 ft.

Maintenance of the Pipes.—Once laid and made tight, the pipes give little trouble. Dredging which has been undertaken by the government in recent years to widen

*Article reproduced from December 30th issue, Engineering News, of New York.

the channel on the north side made it necessary to take up some of these pipe lines, and the oldest pipes were not put down again, as it was found that the erosion of the sand carried by the swift tidal current back and forth across the pipe had worn it thin in spots during its 25 years of service. It was therefore determined to lay an 18-inch main in its place, and this was done.

This erosion of the pipe could be prevented, of course, if the pipe could be buried in a trench across the channel; but the dredging of a trench in 65 ft. depth of water on a bottom strewn with boulders and with the swift tidal current is no easy task. And even if a trench were dug, it would probably be filled by the tidal current before the pipe could be laid in it.

Moreover, the occurrence of any leak in the pipe line is easily detected and repaired by a diver when the pipe line is exposed on the bottom. The city has, in fact, an expert diver at its command whenever his services are required. The number of lines of pipe laid at the two separate crossings is such that the temporary withdrawal of service of one or more lines for inspection or repairs still leaves the city well supplied.

In recent years all additions to the submerged lines have been made with 18-inch pipe instead of the 12-inch originally laid. In laying this heavier pipe, it has been found better to pull it into place in three separate sections instead of in one line, as was done with the 12-inch. After the three sections are in place they are joined by a diver working in about 40-ft. depth of water.

At the first Narrows there have been eleven 12-inch pipes laid; of these, three are still in service. There are two 18-inch pipes, the last of which was laid last fall. At the second Narrows six 18-inch pipes have been laid and are in service.

The flexible pipe used is of the well-known Ward pattern, but has been modified in shape somewhat to reduce the resistance in hauling. A section is shown herewith. This pipe can be deflected 12½° before binding occurs. The pipe is cast in Glasgow and costs $61.50 per long ton delivered at Vancouver. Its weight is about 400 lb. per ft. The total cost of the 18-inch submerged crossings, including the cost of laying, is about $11.50 per lin. ft.

It has occasionally happened that in laying, caulking and testing the pipe a bell has been split at one of the joints. Breaks have also occurred from contact with keels of ships which have gone ashore in the Narrows during foggy weather. Repairs of such breaks have been effected by placing on the pipe to cover the split a sleeve with a stuffing-box and rubber packing at each end.

We are indebted to Edward M. LeFlufy, assistant engineer of the Waterworks Department of Vancouver, for information from which this article has been prepared.

Keuffel & Esser Company, of New York City and Montreal, have purchased the entire stock, good-will, trade marks, etc., of E. G. Soltmann, New York, who recently went into bankruptcy. The stock was inventoried at more than $100,000. It included the Soltmann specialties, which Keuffel & Esser Company will continue to market for engineers and architects.

In the article, "The Use of Pure Iron by Railroads," which appeared in *The Canadian Engineer*, issue of December 30th, 1915, it was stated, "It is possible to make a technically pure iron containing not more than 10 per cent. of carbon, manganese, sulphur, phosphorus and silicon." This sentence should have read: "0.10 per cent. of carbon, manganese," etc.

GROWTH OF STREET RAILWAY TRAFFIC IN RELATION TO POPULATION.*

It is evident that the total street railway traffic in any city is a function of the population, as is also the fact that there is a limit to the riding that any one person may conveniently do; or in other words, after a city has reached a certain period in its growth, the number of rides per capita will tend to become constant.

Estimates of future traffic have formerly been based largely, and in our opinion, falsely, upon the "Law of Squares," which is, that "revenue rides increase as the square of the factor of increase of population."

While this has held, and even up to a critical point in population been exceeded in many cities, consideration shows the fallacy of such assumption as applied throughout the total length of the population scale.

The law manifestly cannot be admitted except as an approximation applied to a city in its earlier periods of growth. The problem is to determine empirical formulæ, which, while covering past conditions, give results which may be reasonably applied to the future.

The increase of riding habit in a growing city, assuming that the facilities for transportation keep pace with requirements, may be divided into two independent factors:—

(a) The normal increase due to an increasing proportion of the city's total population, who, because of distance, ride each day, to and from the central business district, together with the increase due to those who ride for social, shopping or other purposes.

(b) The increase in the actual habit of riding, cultivated by improved transportation.

When population is contained within a circle of, say, one mile radius, a street railway is unnecessary, but as the city grows, and people settle outside this zone, a street railway system becomes essential. The effect of this continued growth is to increase the proportion of those living without the central area, and thus of those who daily ride to such district. While it is a fact that the inner zone usually becomes more densely populated, the actual population added to this area is comparatively small, and for the purposes of this investigation it may be assumed without sensible error, that the whole increase is in the outer zone.

It can be demonstrated, however, that the growth of the total traffic with the increase of population in outlying sections, together with proper transportation facilities, follows a well defined law, which indicates that about 520 is the limit of rides per capita per annum.

Combining the revenue passenger and rides per capita information for Toronto, with that of population growth, the following table for the probable future passenger traffic conditions has been compiled, always assuming adequate development of transportation facilities:—

Year.	Population.	Revenue passengers per annum.	Revenue rides per capita, per annum.
1914	470,000	153,000,000	325
1920	590,000	225,000,000	375
1925	705,000	282,000,000	400
1930	835,000	350,000,000	420
1935	975,000	425,000,000	435
1940	1,135,000	510,000,000	450

* From Toronto Civic Transportation Report

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GRAVEL and slag roofs laid along the lines of The Barrett Specification cover many of the first-class buildings of the Dominion, because the experience of more than 60 years has proven that—

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4th—They take the base rate of insurance and are approved by the Underwriters' Laboratories.

Claims regarding roofing should be met with this question: "How many can you refer to who have used say 500 squares of your roofing on a comparatively flat surface for ten years and bought more?"

Then investigate such claims!

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Exaggerated statements sometimes sell roofing, because the principles of Barrett Specification Roofs are not well known to the purchaser. Once he understands the long service they give and the low unit cost, he will have no other kind.

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BARRETT SPECIFICATION ROOF ON THE GIDEON OUIMET SCHOOL, POUPART STREET MONTREAL

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Roofer—Wm. Pelletier Montreal

Special Note

We advise incorporating in plans the full wording of The Barrett Specification in order to avoid any misunderstanding.

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ROOFING—Shall be a Barrett Specification Roof laid as directed in printed Specification, revised August 15, 1911, using the materials specified and subject to the inspection requirement.

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MONTREAL TORONTO WINNIPEG VANCOUVER

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RAILWAY ORDERS

24565—December 13—Authorizing C.N.O.R. to construct spur for Godson Contracting Co. in Cons. 4 and 5, Lot 8, Tp. Pickering, Ont., and to cross road allowance in Lot 8 with said spur.

24566—December 13—Directing that G.T.R. install gates at highway immediately west of Lorne Park Station, Ont., by June 1st, 1916.

24567—December 14—Directing that Elgin and Havelock Ry. trains operated over three bridges north of Petitcodiac be limited to speed not exceeding 8 miles an hour, pending laying of 8" x 8" ties 12 ft. long, when guard-rails shall be installed; ties and guard-rails be laid by May 1st, 1917; crossing signs to be erected at all highways on said Ry. by Dec. 31st, 1915.

24568—December 11—Authorizing Mont. and Southern Cos. and C.P.R. Companies to operate trains over crossing on Lot 34 (St. Hyacinthe to Farnham), without first being brought to a stop.

24569—December 18—Dismissing complaint City Transfer Co., Edmonton, Alta., re breaches of contract between it and C.N.R., dated Feb. 1st, 1911.

24570—December 14—Approving revised location G.T.R. Branch Lines Co.'s Battleford Branch in Secs. 10, 15 and 22-38-16, W. 3 M., Sask.

24571—December 11—Authorizing Montreal and Southern Co.'s Ry. to operate certain bridges.

24572—December 15—Authorizing C.P.R. to construct industrial siding for Fraser, Ltd., at Victoria, mileage 20.02, Fredericton Sub. Div.

24573—December 10—Approving agreement between Bell Tel. Co. and Camden Independent Tel. Co., Ltd., dated Nov. 30th, 1915; and rescinding Order No. 11929, Oct. 11th, 1910, approving agreement dated Sept. 16th, 1910.

24574—December 10—Approving agreement between Bell Tel. Co. and Urban and Rural Tel. Co., Ltd., dated Dec. 1st, 1915; and rescinding Order No. 12253, Nov. 11th, 1910, approving agreement of Sept. 30th, 1910.

24575—December 20—Extending, until June 30th, 1916, time within which C. N. Ry. equip its cabooses with air-brakes, subject to condition that cabooses already so equipped be kept in service as much as possible.

24576—December 20—Authorizing C.P.R. to construct extension to siding of Pembroke Shook Mills, Ltd., at mileage 106.5, Chalk River Sub. Div.

24577—December 18—Authorizing N. St. C. and T. Ry. to operate spur from its Queenston St. line down Phelps St. a distance of 1,062 ft. in City of St. Catharines, Ontario.

24578—December 20—Authorizing C.N.R. to cross road between Secs. 9 and 8-18-22, W. 1. M., Manitoba.

24579—December 20—Authorizing St. Lawrence and Adirondack Ry. to construct spur across Salaberry St., Valleyfield, Que., for Castings Co. of Canada, Ltd.

24580—December 18—Directing C.P.R. to fence right-of-way on Sirdar Sub. Div. from mileage 75.45 to 77, Province of B.C.; work be completed by May 15th, 1915.

24581—December 17—Authorizing C.P.R., at own expense, to construct road diversion across its Outlook Sub. Div., mileage 48.4, proposed road diversion comprising Pt. N.E. ¼ Sec. 33-21-2, W. 3.

24582—December 18—Extending, until May 15th, 1916, time within which G.T.P. Ry. fence Ballast Pit, on edge Souris River Valley, Regina-Boundary Branch, known as Souris Pit.

NEW INCORPORATIONS.

Castor, Alta.—Farmer's Hardware, Limited, $20,000.

New Westminster, B.C.—Western Canada Lime Company, Limited, $100,000.

Port Arthur, Ont.—The Western Machinery Company, Limited, $40,000. R. E. Roberts, P. F. Munroe, W. F. Langworthy.

Toronto, Ont.—Swastika Gold Mines, Limited, $2,000,000. D. I. Grant, G. Adams, E. Smily; Consolidated Steel Company, Limited, $100,000. W. H. Beatty, F. A. Hammond, C. B. McClurg.

COAST TO COAST

Brantford, Ont.—The new Brantford Municipal Railway Board was formed last week, consisting of C. H. Hartman, F. J. Calbeck and W. R. Turnbull.

North Vancouver, B.C.—David B. Boyd, of Vancouver, is asking for exemption from taxation and free water for a shipbuilding industry on the north shore water front.

Toronto, Ont.—J. W. Leonard, superintendent of the Toronto Terminal Company, states that the structural work on the new Union Station will be commenced next June, provided the steel can be obtained.

Winnipeg, Man.—The Munro Steel and Wire Works, Limited, have moved their plant to Elmwood and amalgamated with the Hero Manufacturing Co., Limited, increasing their combined capital to $100,000.

South Vancouver, B.C.—S. B. Bennett, municipal engineer, in his annual report to the council, states that about 1½ miles of streets were graded during 1915, nearly 2 miles of streets were macadamized, over 4¾ miles of sewers were constructed, and about 2 miles of water mains (4-in., 6-in., 8-in. and 12-in.) were laid.

Glacier, B.C.—Foley Bros., Welch & Stewart, contractors, report that the progress of the Roger's Pass tunnel for the past year has been 3½ miles of heading and 2 8/10 miles of double-track tunnel enlargement. The heading has now been finished and the progress in tunnel enlargement is averaging somewhat over 50 ft. per day.

Winnipeg, Man.—The contracts in connection with aqueduct construction awarded by the Greater Winnipeg Water District to November 30th, 1915, amounted to $11,640,567. The estimate for the whole work was $13,045,600. The amount paid out on contracts was $3,468,406, and there was a balance to be paid of $156,998.

Ottawa, Ont.—The Dominion Government is negotiating for a new arrangement with the New Brunswick Government in regard to the operation of the St. John Valley Railway. Under the present contract, the Intercolonial pays 40 per cent. of the gross receipts, which is said to mean a considerable loss to the government railway system.

Vancouver, B.C.—The first portions of protective work to safeguard the city's water mains, from the intake station on the Capilano River to a point over a mile and a half south, have been completed at a cost of about $8,500, under the supervision of F. L. Fellowes, city engineer. It is expected that the remainder of the work will be completed this year.

Toronto, Ont.—The estimates for this year's work on the Toronto harbor, which were passed by the board of harbor commissioners last week, amount to $2,500,000. Of this sum $650,000 is for reclamation work, $100,000 for the proposed lift bridge over the Don at Cherry Street, and the remainder for various construction works. Last year there was spent $1,200,000.

Winnipeg, Man.—All contracts entered into between C. H. Simpson and the Government of Manitoba in connection with the construction of the Winnipeg law courts building, are to be ignored, and two valuators will determine the amount which the contractor is to receive, according to an agreement made by the parties and approved of by the chief justice, who has been conducting the law courts inquiry.

New Toronto, Ont.—Water pipes have been laid to about thirty residences in this village from the municipality's new waterworks system, and it is expected that water will be supplied very soon. Mimico has arranged to take 50,000 gallons per day, which will necessitate the erection of a large standpipe on the boundary line between the two municipalities. The Grand Trunk Railway has also signed a contract for a large supply.

Hamilton, Ont.—According to the report of H. E. Waterman, secretary of the harbor board, the appropriations last year for the development of the harbor amounted to $400,000, of which $250,000 represented a preliminary appropriation for the development scheme at Stipes' Inlet, the total cost of which will be about $2,000,000. Dredging operations were continued on a larger scale than in 1914, with 247,643 cubic yards dredged. The new dock wall was completed on December 18th, the total cost of the work being about $225,000.

PERSONAL.

A. R. MACGOWAN has been appointed principal assistant engineer of the Canadian Government Railways.

D. E. RUDD has been elected chairman of the Sewerage and Public Works Commission at Guelph, Ont.

GEORGE J. GUY has been elected chairman of the harbor board of Hamilton, Ont., succeeding commissioner W. J. Clark.

FRED O. CONDON has been appointed division engineer of districts 3 and 4 of the Intercolonial Railway, and of the Prince Edward Island Railway, with headquarters at Moncton, N.B.

F. W. SUMNER, of Moncton, N.B., has been elected president of the St. John and Quebec Railway Company, in succession to Mr. Irving R. Todd, of St. Stephen, who recently resigned.

WILLIAM ASHMAN, of Moose Jaw, Sask., formerly chief of the department of investigation, Saskatchewan division of the Canadian Pacific Railway, has been promoted to the office of assistant to Major MacLeod, assistant chief of the department for the entire C.P.R. system. W. G. Cheesier, chief of the Alberta department, succeeds Mr. Ashman at Moose Jaw.

HENRY W. HODGE, M.Can.Soc.C.E., M.Inst. C.E., has been appointed as public service commissioner of New York State. Mr. Hodge is a consulting engineer, with offices in New York City, and is well known in Canada, having been retained by the government in a consulting capacity in connection with the new design for the Quebec Bridge. He is a director of the American Society of Civil Engineers, and a member of the council of the American Institute of Consulting Engineers. The firm of Boller, Hodge & Baird, in which he is a partner, were the engineers for the Singer Tower, the Metropolitan Tower, and many other important structures in New York.

OBITUARY.

JERRY J. FLYNN, assistant superintendent of the old Welland Canal since 1896, died in St. Catharines on January 7th. Mr. Flynn was born in Hamilton.

FRANK HOLDER, a graduate of Queen's University, was murdered last week at Hammond, Ind. Mr. Holder was general foreman of the erecting department of the Standard Steel Car Company's plant at Hammond. He was born at Kingston, and was 50 years of age.

WILLIAM WESTLAKE, a contractor, died at Whitby, Ont., recently. Mr. Westlake had erected many buildings in Whitby, Oshawa and Bowmanville before he retired from business fifteen years ago. He was born in Yorkshire, England, and came to this country when ten years of age.

GRAHAM FRASER, one of the founders of the iron and steel industry in Canada, died December 25th, 1915, at New Glasgow, N.S. In 1872, Mr. Fraser and others established the Hope Iron Works. In 1881 he was one of the organizers of the Nova Scotia Steel Company. When that company had acquired coal mines in Cape Breton and had developed ore deposits in Newfoundland, it became the Nova Scotia Steel and Coal Company.

Pte. ALEX. MURRAY, who was the son of T. Aird Murray, consulting engineer, of Toronto, died last week in England, as a result of wounds received on the firing line. Mr. Murray, who was a student at S.P.S., Toronto, was 22 years of age. He went to the front with the first contingent, as a member of the Queen's Own Rifles, and served through the battles around Ypres. Some months ago he survived an attack of spinal meningitis, and returned to the trenches, only to be fatally wounded not long afterwards. He will be buried at Newcastle, England, where he was born.

COMING MEETINGS.

AMERICAN FORESTRY ASSOCIATION.—Annual meeting to be held at Boston, Mass., January 17th and 18th, 1916. Secretary, P. S. Ridsdale, Washington, D.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Fourteenth annual convention to be held at Toronto January 18th to 20th, 1916. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

AMERICAN WOOD PRESERVERS' ASSOCIATION.—The Twelfth Annual Convention to be held in Chicago, January 18, 19 and 20, 1916. Chas. C. Schnatterbeck, chairman, Committee on Publicity and Promotion, American Wood Preservers' Association, Baltimore, Maryland.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—The Thirtieth Annual Meeting to be held in Montreal, January 25, 26 and 27, 1916. Secretary, Prof. C. H. McLeod, 176 Mansfield Street, Montreal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—To be held in Chicago, Ill., February 4th, 1916. Joint dinner that evening with American Electric Railway Manufacturers' Association.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Second National conference to be held at Chicago, Ill., February 15th to 18th, 1916. Secretary of Advisory Committee, J. P. Beck, 208 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION.—Annual Convention to be held in Chicago, February 17 and 18, 1916. Secretary, E. S. Hanson, 538 S. Clark Street, Chicago, Ill.

CANADIAN LUMBERMEN'S ASSOCIATION.—At Ottawa, February 18th, 19th and 20th, 1916, annual convention. Frank Hawkins, secretary, Ottawa.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—At Sohmer Park, Montreal, March 6th to 10th, 1916. Geo. A. McNamee, secretary, New Birks Building, Montreal.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

CANADIAN SOCIETY OF CIVIL ENGINEERS.

THIRTIETH ANNUAL MEETING TO BE HELD AT MONTREAL NEXT TUESDAY, WEDNESDAY AND THURSDAY—SUMMARY OF ACTIVITIES FOR PAST YEAR AND PROGRAMME TO BE FOLLOWED NEXT WEEK.

SEVERAL hundred members of the Canadian Society of Civil Engineers will attend the thirtieth annual meeting, to be held next week in the rooms of the Society, 176 Mansfield Street, Montreal.

The first session will open at 10 a.m., Tuesday, January 25th, with the reading of minutes and the appointment of scrutineers. The reports of council, library committee and treasurer will be heard, as well as a special report from the finance committee. After hearing the reports of branches, the meeting will adjourn at 1 p.m., to meet again at 3 p.m.

In the afternoon session, the reports of the following committees will be heard and discussed: Cement Specifications, Conservation, Roads and Pavements, Electrotechnical Commission, Steel Bridge Specifications, Educational Requirements, Sewage Disposal and Sanitation, Reinforced Concrete, General Clauses, Cast Iron Water Pipes and Specials. In the evening a complimentary smoker will be held in the Society's building.

Inspection trips to various manufacturing establishments in Montreal will be enjoyed Wednesday morning, and in the afternoon the members will continue to receive reports of committees and to act thereon. At 4.30 p.m. the retiring president will deliver an address. An informal dinner, complimentary to visiting members, will be held at eight o'clock that evening at the Engineer's Club.

Francis Clark Gamble,
President, Canadian Society of Civil Engineers.

George Herrick Duggan,
President-Elect.

At ten o'clock Thursday morning the members will meet again to receive the reports of scrutineers. The newly elected president will take the chair, after which various new and unfinished business will be discussed, which will complete the annual meeting. In the afternoon there will be a session of the new council.

By courtesy of the Eastern Canadian Passengers' Association, members and their families who have paid a full one-way first-class fare going to the meeting, will be returned free on presentation of a standard convention certificate signed by the ticket agent from whom the one-way ticket was procured.

This annual meeting will mark the retirement from the presidency of the Society of Francis Clarke Gamble, C.E., the first man from the Pacific Coast who has had the honor of being elected to that office. Mr. Gamble was born in Toronto in 1848, being the son of Clarke Gamble, Q.C. He was educated at Upper Canada College, Toronto, and at Rensselaer Polytechnic Institute, Troy, N.Y. He began his engineering career on the staff of the Intercolonial Railway in 1869, and two years afterwards joined the staff of the Great Western Railway as assistant engineer.

In 1873 Mr. Gamble became resident engineer for the contractors on the construction of the Prince Edward

Prof. Clement Henry McLeod, Ma.E.

Secretary, Canadian Society of Civil Engineers.

Prof. McLeod is one of the most widely known men in Society circles, having been secretary of the Society during its entire existence, with the exception of only the first four and a half years. This means that he has given 24½ years of service to Can Soc. C.E. work. He is vice-dean of the engineering faculty at McGill University, and is an authority upon astronomy, surveying and geodesy. His astronomical work has attracted considerable attention in scientific circles, and some of his writings on surveying and geodesy are used as texts. He is a Fellow of the Royal Society of Canada, a life member of the Royal Astronomical Society of Canada, and a member of numerous other organizations.

Island Railway. He again entered the employ of the Intercolonial Railway in 1876, as assistant engineer, and later, in the same capacity, served the Q.M. & O. Railway until 1878. Part of the following year was spent in private practice, but in 1879 he became first assistant engineer of construction for the Canadian Pacific Railway at Rat Portage, afterwards renamed Kenora, Ont. In 1880 the company sent him as principal assistant engineer to British Columbia, where he later became connected with provincial government work as assistant engineer.

He was transferred to the Department of Public Works of Canada, where he served as assistant engineer from 1881 to 1887, then being appointed resident engineer and government agent for the Department, which position he held until 1897, when he resumed private practice. His engineering ability had been thoroughly recognized by the British Columbia government, however, and the provincial authorities soon persuaded him to enter their employ again as public works engineer and inspector of dykes, which position he filled from 1898 until 1911. Since that time he has been chief engineer of railways for the province, with headquarters at Victoria, B.C.

Mr. Gamble was a charter member of the Canadian Society of Civil Engineers, and has been of considerable service to the Victoria and Vancouver branches in organizing their activities. He served a successful term as chairman of the Victoria branch. Previous to his election to the presidency, Mr. Gamble had been a member of the council of the Society twice—in 1892 and in 1898—and in 1913 and in 1914 he was one of the vice-presidents. He was elected a member of the Institution of Civil Engineers of Great Britain in 1891, and a member of the American Society of Civil Engineers the same year.

Mr. Gamble will be succeeded as president by George Herrick Duggan, vice-president and general manager of the Dominion Bridge Co., Montreal. Mr. Duggan was born in Toronto in 1862, and is the only son of the late John Duggan, Q.C. He was educated at Upper Canada College, Toronto, and at the School of Practical Science, Toronto University. Like so many other Canadian engineers, Mr. Duggan began his engineering career with the Canadian Pacific Railway, but in 1891 became chief engineer of the Dominion Bridge Company, which position he retained until 1901, when he became assistant to the president and consulting engineer of the Dominion Iron and Steel Co. In 1904 Mr. Duggan was appointed second vice-president and general manager of the Dominion Coal Co., but in 1910 rejoined the Dominion Bridge Co. as general manager.

Mr. Duggan was elected to associate membership in the Canadian Society of Civil Engineers in 1888, and two years afterwards qualified as a member. He is also a member of the Institution of Civil Engineers of Great Britain, the American Society of Civil Engineers, and the Canadian Mining Institute. He was vice-president of the Canadian Society of Civil Engineers in 1900, 1901, 1902, 1903 and 1908, and also served as a councillor of the Society for nine years.

He is an enthusiastic sailor, and was one of the founders of the Toronto Yacht and Royal St. Lawrence Yacht Clubs. He designed and sailed the winner of the Seawanhaka International Cup, and successfully defended that prize from 1896 till 1901.

Mr. Duggan is a very busy man at the present time, as he is a director of the Montreal Ammunition Co., and is also chief engineer of the St. Lawrence Bridge Co., having charge of erection of the new Quebec bridge.

Nominees for vice-president of the society to be elected this year are Joseph G. Legrand, bridge engineer, Grand Trunk Pacific Railway, Winnipeg, Man., and Thos. H. White, chief engineer, Canadian Northern Pacific Railway, Vancouver, B.C.

The nominees for council are as follows (two members are elected from District One and one member from each of the other districts):—

District 1—Jules Duchastel, town engineer of Outremont, P.Q.; W. J. Francis, consulting engineer, Montreal; H. R. Safford, chief engineer, Grand Trunk Railway, Montreal; Julian C. Smith, chief engineer, Shawinigan Water and Power Co., Montreal.

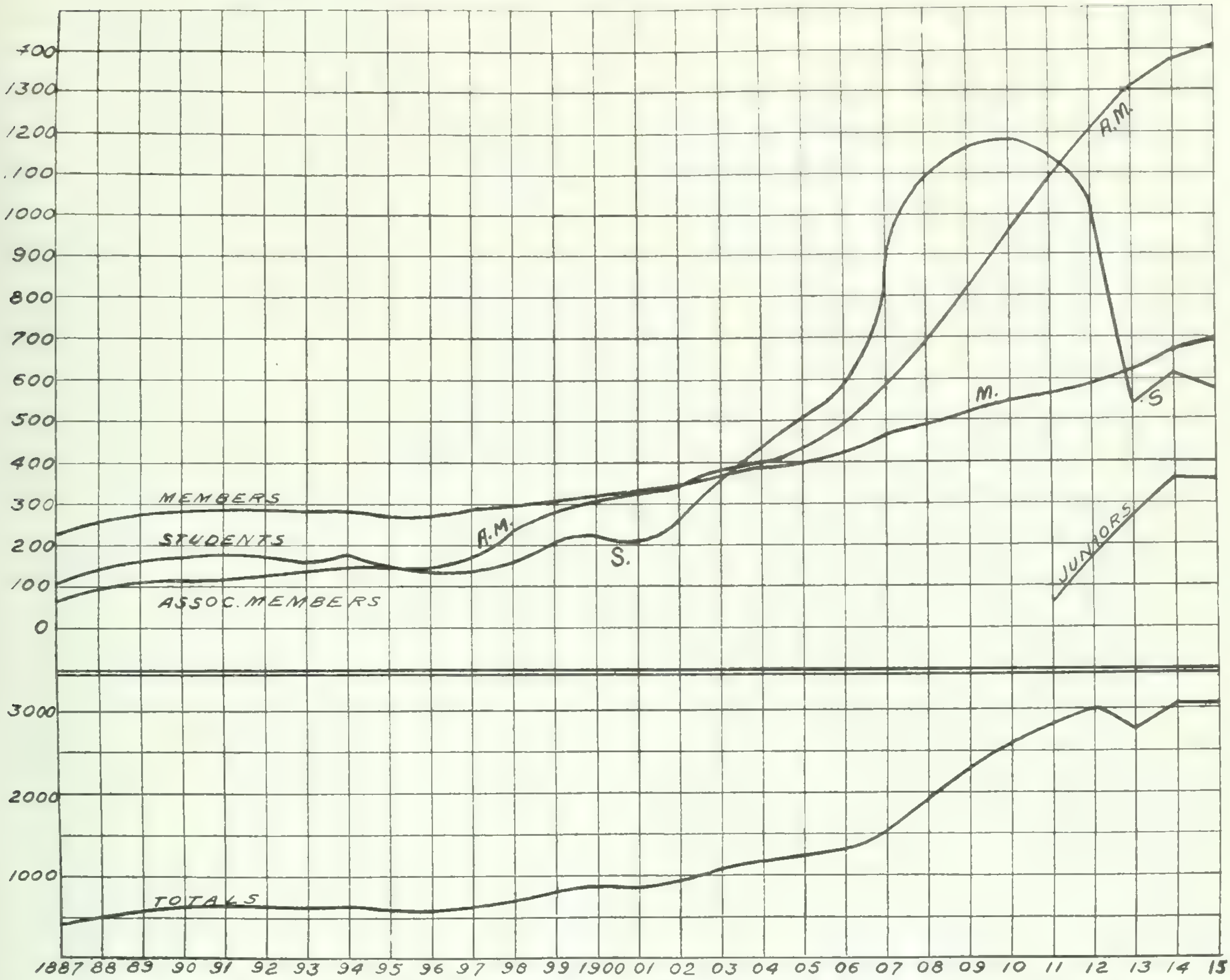
District 2—J. L. Allan, Dartmouth, N.S.; H. Donkin, deputy minister of public works and mines, Halifax, N.S.

District 3—A. E. Doucet, Transcontinental Railway, Quebec, P.Q.; L. A. Vallée, engineer and director of railways, Parliament Buildings, Quebec.

District 4—E. D. Lafleur, chief engineer, Dept. of Public Works of Canada, Ottawa; W. P. Wilgar, assistant district engineer, Transcontinental Railway, Cochrane, Ont.

District 5—J. R. W. Ambrose, chief engineer, Toronto Terminal Railway Co., Toronto; A. L. Hertzberg, division engineer, Canadian Pacific Railway, Toronto.

GROWTH OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.



Top Curves Show Growth of Each Class of Membership. Bottom Curve Shows Growth of Total Membership.

District 6—C. H. Dancer, deputy minister and chief engineer of public works, Parliament Buildings, Winnipeg; D. A. Ross, consulting engineer, Winnipeg.

District 7—D. O. Lewis, district engineer, Canadian Northern Railway, Victoria, B.C.; Alfred O'Meara, Victoria, B.C.

Extracts from Report of Council.—Election during the year resulted in 14 members being added to the roll, 66 associate members, 2 associates, 23 juniors and 42 students. One former member was reinstated, and 17 associate members became members, 12 juniors and 19 students became associate members, and 10 students became juniors.

There were removed from the rolls by resignation or on account of non-payment of dues, 5 members, 34 associate members, 3 associates, 11 juniors and 51 students. The resignations were due to the fact that those concerned had ceased active engineering work or were unable to pay the annual dues.

Twenty-seven deaths were reported during the year, including two honorable members, Sir Sandford Fleming and Thos. C. Keefer, C.M.G.

At present the total membership is 3,076, an increase of 17 over last year. The following table is a summary of the membership as at the close of 1914 and at the close of 1915:—

	1914.	1915.
Honorary members	10	8
Members	674	693
Associate members	1,372	1,409
Associates	36	34
Juniors	352	357
Students	615	575
Total	3,059	3,076

The membership of the branches at the date of the last annual meeting was as follows:—

	Corporate.	Non-Corporate.	Total.
Quebec	51	28	79
Ottawa	161	55	216
Kingston	14	13	27
Toronto	138	104	242
Manitoba	101	48	149
Calgary	41	6	47
Vancouver	112	20	132
Victoria	52	9	61
Edmonton	32	8	40
Regina	23	4	27
	725	295	1,020

There have been 3 sectional meetings, 8 monthly meetings and 2 junior section meetings during the year. The council held 20 meetings during the year.

The following papers were presented during the year:

"Movable Dams," by Mr. H. B. Muckleston, M.Can. Soc.C.E.

"Shell Manufacture," by Mr. H. H. Vaughan, M.Can.Soc.C.E.

"Lethbridge Sewage Disposal Works," by Mr. A. C. D. Blanchard, M.Can.Soc.C.E.

"Heavy Guns Used in the Field," by Col. Lacey R. Johnson, M.Can.Soc.C.E.

"The Jordan River Power Development," by Mr. Chas. A. Lee, A.M.Can.Soc.C.E.

"Edmonton's Tunnel Sewerage System," by Mr. A. J. Latornell, A.M.Can.Soc.C.E.

"Tests on Shearing Resistance of Reinforced Concrete Beams," by Messrs. E. Brown, A.M.Can.Soc.C.E., H. M. MacKay, M.Can.Soc.C.E., and C.M. Morssen, M.Can.Soc.C.E.

"Decay in Wood." Discussion on, introduced by Mr. F. B. Brown, M.Can.Soc.C.E.

"The Stave Falls Power Development of Western Canada Power Company, Limited," by Mr. R. F. Hayward, M.Can.Soc.C.E.

"Aviation," by Mr. J. A. D. McCurdy.

"The Development of Power in the St. Lawrence River at Cedars Rapids by the Cedars Rapids Manufacturing & Power Company," by Mr. Henry Holgate, M.Can.Soc.C.E.

"Constant Voltage Operation of a High Voltage Transmission System," by Dr. L. A. Herdt, M.Can.Soc. C.E., and Mr. E. G. Burr, A.M.Can.Soc.C.E.

"Hydraulic Development and Construction at Cedars Rapids," by Mr. J. C. Smith, M.Can.Soc.C.E.

"Electrical Design and Construction of the Cedars Rapids Manufacturing and Power Plant," by Mr. R. M. Wilson, M.Can.Soc.C.E.

"The Sea Sled," by Mr. B. O. Smith, Junior Can. Soc.C.E

"The Cost of Modern Houses," by Mr. D. Bremner, S.Can.Soc.C.E.

The Committees on Track and on Rails have been discontinued for the present in view of the fact that the functions of these committees are overlapped by the similar committees of the American Railway Engineering Association.

A Committee on Roads and Pavements has been added to the list of those named at the annual meeting.

The Committee on Cement Specifications, which has been reconstituted, has presented a report with a proposed standard specification. The specification will come before the annual meeting for discussion and adoption. Reports have also been distributed to the membership for consideration in advance of the annual meeting by the Committees on Conservation, Roads and Pavements, the Electro-Technical Commission, Steel Bridge Specifications, and Educational Requirements.

Early in the year the council made a representation to the Department of Railways and Canals, at Ottawa, to the effect that the Society's specification for steel bridges should be adopted by the Dominion Government. The matter is still under the consideration of the chief engineer of the department.

The special September meeting of the council, in connection with which during the past two years the travelling expenses of members from outside points have been paid by the Society, was not convened this year owing to the financial situation. The council, however, considers that in view of the importance of unifying the interests of the members residing in various parts of the country, it will be desirable, so soon as the funds at the disposal of the Society permit, to establish a regular series of council meetings for which a liberal mileage payment shall be made to non-resident members. It is suggested that at the outset possibly three such meetings during the year held in the months of January, May and September might be advantageous.

The following is a statement in regard to the members of the Society who have, so far as information has been received, enlisted for overseas service:—

Honorary member	1
Members	34
Associate members	144
Associate	1
Juniors	85
Students	89
In all	354

Of these there have been killed in action or died of wounds:—

Members	2
Associate members	4
Juniors	5
Student	1
In all	12

The special funds for which subscriptions have been received from the members are as follows:—

Fund in aid of families of members who have enlisted for active service in the army, total	$2,093.00
There has been paid out on account of this fund	132.40
Canadian Engineers' Hospital and Medical Comforts Fund, total	703.45
There has been paid out on account of this fund	450.55

The proposed excursion to the Pacific Coast, in connection with which free haulage of the Society's train had been generously provided for by the Grand Trunk, Transcontinental, Grand Trunk Pacific and Canadian Pacific Railways, had to be abandoned on account of the very small number of members (nine in all) who said they would avail themselves of the privileges extended to them.

There are now ten branches of the Society, the last to be formed being that at Regina, at present under the chairmanship of Mr. O. W. Smith.

The first Provincial Division to be formed under Bylaw 54 was organized in Vancouver, for British Columbia, in July last and duly authorized by the council at its meeting on July 20th.

Early in the year an effort was made to have this Society placed upon the list of educational institutions from which, under the city charter, the civic tax is not exigible. The matter is again being taken up, it is hoped with some promise of success.

On the request of some of the members interested, the council has memorialized the Dominion Government asking for the appointment of a commission to revise the Patent Act.

An effort will be made during the approaching session of the Dominion Parliament to obtain an Act defining the term "civil engineer."

Some consideration has been given during the year to publicity matters affecting the profession of civil engineering. A circular is about to be issued with a view to instructing municipalities as to the advisability of employing only corporate members of the Society. It is also proposed to request corporate members when advertising

(Continued on page 158.)

GROUTING UNDER CANAL LOCK WALL FOUNDATION

FORMING A WATERTIGHT CUT-OFF THROUGH SEAMY ROCK FOUNDATION UNDER THE WALLS OF LOCKS ONE, TWO AND THREE OF THE NEW WELLAND SHIP CANAL.

By Eric P. Muntz, B.A.Sc., Assistant Engineer, Welland Ship Canal.

THE seamy nature of the red Medina shale, which forms the foundation of Locks 1, 2 and 3 of the New Welland Ship Canal, necessitates a "cut-off" under the lock walls to prevent seepage. This is necessary not only to prevent damage to the foundation, but to keep excessive upward pressures from being exerted on the slab forming the floor of the lock chamber.

The "cut-off" may be effected either by cutting trenches in the foundation or by grouting. The grouting method entails the drilling of holes sufficiently close together that grout applied under pressure will find out the open seams, if any, and extend sufficiently to meet grout from the adjoining holes, and thus form a watertight "cut-off."

The chief objections to the first of these methods are the cost of excavation, the tendency in this class of material to break back and shatter the sides of the trench when excavating, and the cost of extra concrete required to fill the trench. The grouting method requires only the drilling of two lines of holes, three inches in diameter and ten feet apart, one line under the heel and another under the toe of the wall, and the application of the grout. The actual grouting requires but four men, who can complete twelve holes per day, twelve holes representing the foundation of one 60-foot monolith.

At Lock 2 the sub-foundation trenches of both east and west lock walls were taken out by an 85-ton Marion-Osgoode shovel. The sub-foundations are 52 feet wide in the bottom and average 17 feet deep, which permitted two cuts, horizontally and vertically. While the shovel was completing the last cut the drills were started behind it, thus making sure of having the drilling done well in advance of the concrete.

After the shovel had "dug out," all loose material remaining was removed by hand. This at times was considerable, owing to irregularities in the rock surface. The rock was then gone over with wire brooms and a hose until thoroughly clean. This final uncovering and cleaning of the rock had to be left until only a few hours before concreting, owing to its tendency to disintegrate very rapidly upon exposure.

When the cleaning up was sufficiently far advanced, so that no loose material remained around the drill-holes, they were pumped out and their tops trimmed so that a tapered circular plug, such as that shown at the left of Fig. 2, driven into them would form a tight joint. Several white pine plugs, 6 inches in diameter at the top, 2½ inches at the bottom and 12 inches long, were provided, with a 1½-inch hole bored down the centre. After driving the plug tight a 1½:1¼ reducer was screwed into the plug, from which a 1½-inch rubber hose pipe led to a small hand diaphragm pump fitted with a pressure gauge. A tub of cement grout—1 part of cement to ⅓ part of water—completed the equipment.

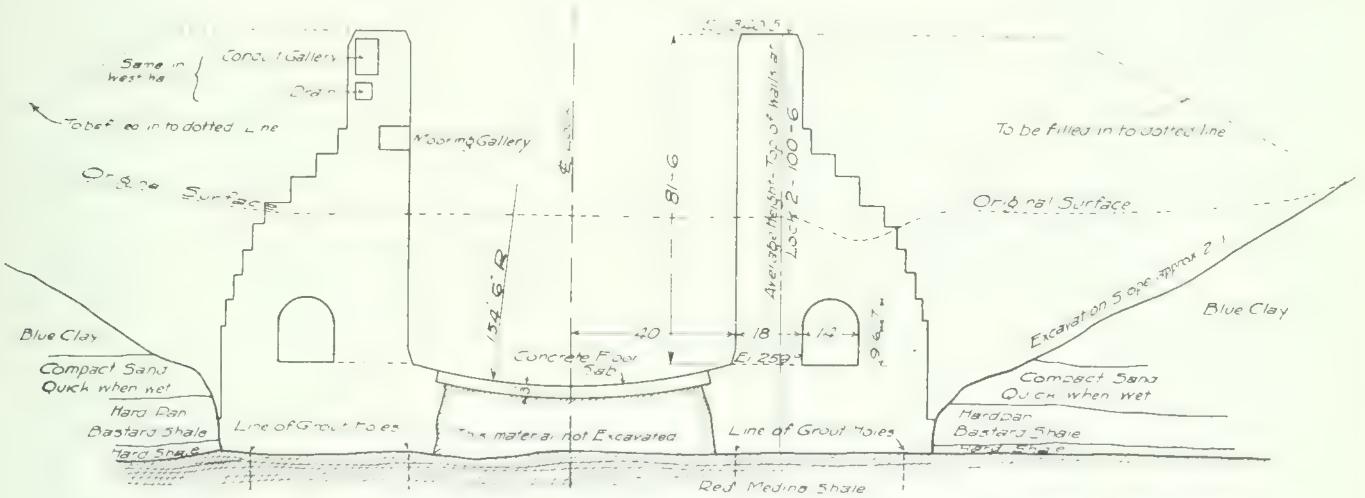


Fig. 1.—Typical General Section Through Excavation and Walls of Lock 2, Welland Ship Canal.

The hole was then filled with grout, the joint at the top of the plug being left loose to permit the air in the hole to escape. The joint was then tightened and the pressure applied. If the pressure rose to 20 pounds and remained stationary without further pumping, the material below was considered sufficiently tight. If the pressure did not rise, or if it rose and fell with the pumping, indicating that grout was entering some seam below, the pumping was continued until the pressure rose or the grout showed on the surface, necessitating abandoning the hole, temporarily at least.

Several instances occurred where the grout showed almost immediately at several points within a radius of a few feet. After removing the surface layer the lower material was found tight. Pockets of poor material on the surface of the foundation have been formed by action of the grout and have subsequently been removed. A seam of poor material, 1½ feet deep and several feet wide, running diagonally across the foundation, was also located in this way. This seam occurred at a point where there was a slight fault in the rock.

How readily the grout will run, where there is a passage through which water may pass, has been demonstrated very clearly. It has frequently run from one hole to the neighboring holes, and on more than one occasion has run across the foundation, showing in the other line of holes about 45 feet away. In one instance a hole on one side took grout readily at 6 pounds pressure. After pumping in about 30 gallons the grout in an adjoining hole ten feet away began to run. This hole was plugged and the pumping continued. After injecting 120 gallons, grout was seen rising in a hole on the other side of the trench. This hole was plugged and pumping continued. The pressure rose to 20 pounds when 130 gallons had been injected, and held there. No further grout could be injected, and after removing the plugs some hours later the grout showed no tendency to rise. On several occasions test-holes have been broken out and seams lifted after a neighboring hole has taken a considerable quantity of grout. The manner in which the grout penetrated through material not closely bonded together and filled interstices between different layers was very clearly demonstrated.

Fig. 2.—Simple Grouting Equipment Used at Lock 2, Welland Ship Canal.

Much of the grouting seemed to indicate that in most cases only the surface layers were sufficiently separated to allow grout to be forced between them. At the same time test-holes showed that the material was too good to warrant excavation. Accordingly a plug was made which could be lowered into the hole, and which would plug it at any desired distance from the surface. Thus, if a hole, or number of holes, on being tried from the surface took readily, the depth of the seam could be located. In some cases this seam or layer was as thick as 8 inches and only about 1½ feet from the surface. It was here considered better to cut shallow trenches through the surface on either side of the foundation than to take time to inject sufficient grout to ensure a perfect cut-off. The grouting below this seam was all done from the surface before the trenches were cut by dropping the plug just below the seam. The details of the plug are shown in Fig. 3. It has worked so satisfactorily that the wooden plugs first used have practically been abandoned.

Pumping the holes out before commencing grouting proved unsatisfactory, as it was hard in this way to thoroughly clean the holes to their full depth. Latterly, therefore, the hose pipe has been connected to a 1½-inch pipe, 12 feet long, inserted in the hole, and water has been forced through from the pump until the overflow at the top of the hole ran clear, indicating the hole to be clean for its full depth. After cleaning a hole in this way grout is pumped through the same pipe until the hole is filled. The pipe is then removed and the plug inserted.

In all, 170 holes have been grouted at Lock 2 since the beginning of September. About 50 per cent. of these took grout, and averaged twenty to thirty gallons to a hole, the range being as high as 180 gallons.

At the end of the season (20th December) the sub-foundation of the west wall had been completed to the main culvert floor excepting two monoliths at the north end of the wall, and the sub-foundation of the east wall to a few feet below the floor. It is interesting to note that had trenches been required in the foundation a great loss of time would have resulted. The scarcity of labor and lack of time, as it was, made it difficult to keep the cleaning up ahead of the concrete. Concreting the sub-foundations did not start until the beginning of September, and it was imperative to fill the sub-foundations to prevent their sides sloughing off and the possibility of larger slides filling the trench before spring.

The grouting has been carried on by the engineering staff of Section 2, of which E. G. Cameron, B.Sc., is Resident Engineer, under J. L. Weller, C.E., Engineer-in-Charge of the Welland Ship Canal for the Department of Railways and Canals, Canada.

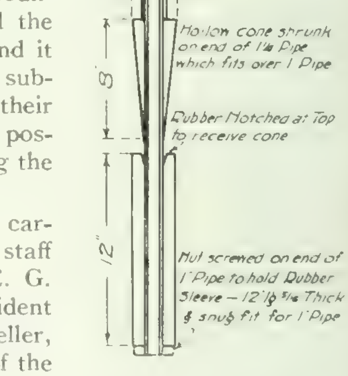


Fig. 3 — Details of Plug used for Deep Grouting.

The new Civic Improvement League of Canada is holding a conference at Ottawa to-day, with representatives present from all nine provinces and most of the large cities. Sir John Willison is chairman. Questions of municipal government and finance, public health, town planning, unemployment, housing, and local improvements, are being dealt with.

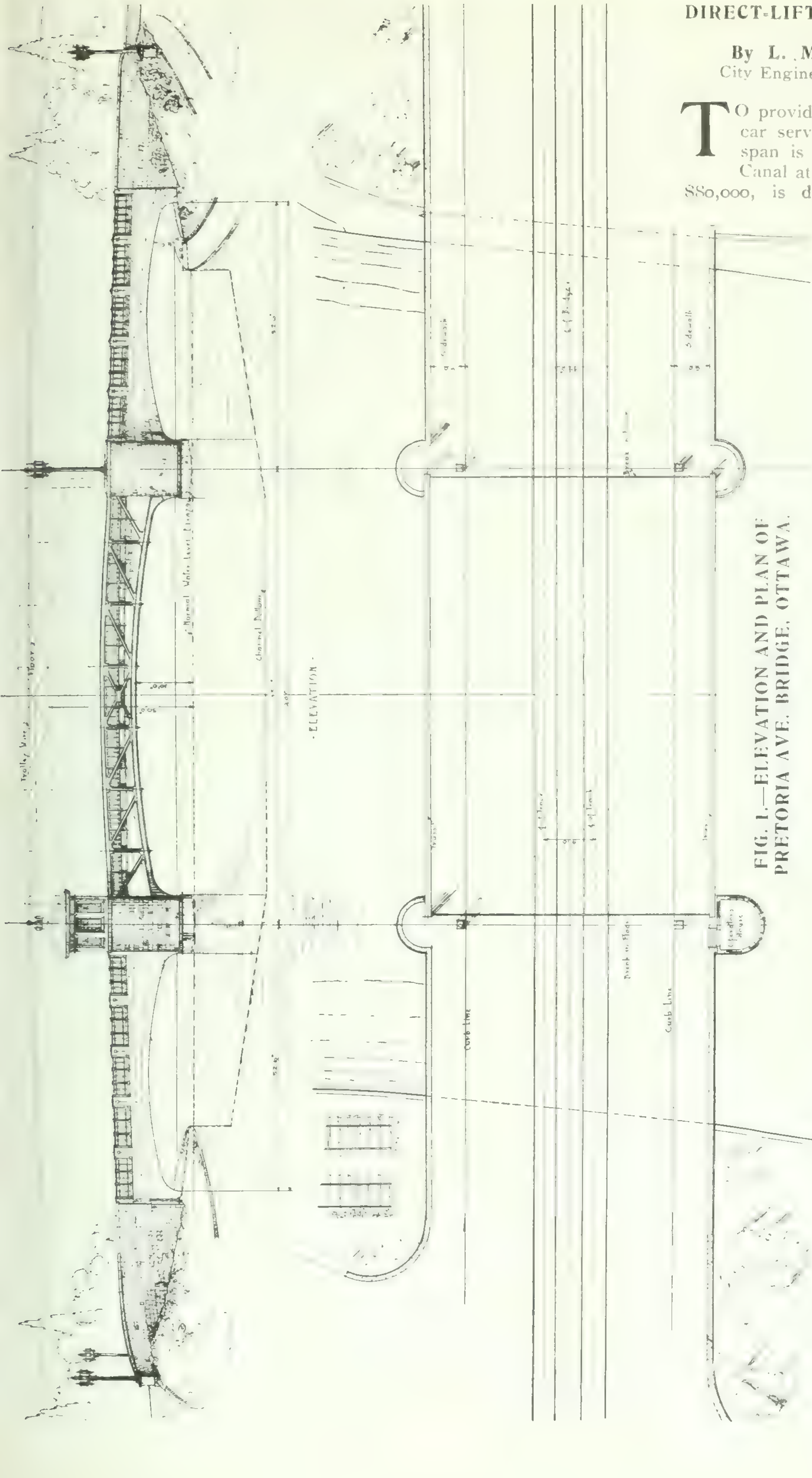


FIG. 1.—ELEVATION AND PLAN OF PRETORIA AVE. BRIDGE, OTTAWA.

DIRECT-LIFT BRIDGE AT OTTAWA.

By L. McLaren Hunter, C.E.,
City Engineer's Department, Ottawa.

TO provide Ottawa East with a street car service, a bridge with direct-lift span is being built over the Rideau Canal at Pretoria Avenue. The cost, $80,000, is divided equally between the Dominion Government and the city of Ottawa.

The bridge consists of two 52-ft. 6-in. reinforced concrete arches and one 95-ft. steel lift span, making a total length of 200 ft. between abutments. The width is 56 ft. from railing to railing, the roadway being 44 ft. wide, and each of the two sidewalks 6 ft. wide.

Twelve-inch piling was driven, in 50-ft. lengths, for the foundation of the piers. These piles were tested to 17 tons per pile. A 1:3:5 mixture is being used for the abutments. The abutment walls are 7 ft. wide at the base, 18 in. at the top. Above the water line the abutments are being faced with sandstone.

The contract for the piers was let to R. Brewster, of Ottawa. One abutment has been completed and practically all of the piling has been driven.

There is a 10-ft. clearance under the lift span when lowered, and 30 ft. when raised, which is sufficient for any boat that is likely to use the canal. The bridge is to be paved with creosoted wood block, laid on 2-in. creosoted planks, with 4-in. by 6-in. creosoted joists placed at 12-in. centres.

Fig. 2 shows the west approach. This approach was originally intended to follow the course of the existing driveway, shown by dotted lines, but this would have made a very heavy grade and an exceptionally bad curve for vehicular traffic and street cars. Permission was therefore secured from the Ottawa Improvement Commission to swing the bridge in a large curve, as shown on the drawing. The grade on the approach will be 4.5 per cent. instead of 6 per cent. as on the

original plan. From the turn of the new driveway to the bridge, the grade will be 3 per cent.

Robert Henham, bridge engineer of the city engineer's department, Ottawa, was in charge of the design of the bridge, and the construction work is under the supervision of Frank C. Askwith, acting city engineer.

Fig. 2. Plan of Approaches to Pretoria Ave. Bridge, Ottawa.

Tenders have not yet been called for the structural steel, but the specifications and detailed plans are practically complete, and tenders will likely be called next month.

A further article regarding the design of the lift span and the methods of construction, will be published in *The Canadian Engineer* in an early issue.

GREAT BRITAIN'S CREOSOTE OIL TRADE.

When war was declared, both Great Britain and Germany placed an embargo on the exportation of creosote oil. In Germany the embargo still exists, but early in 1915 the British Government released tank steamers for the purpose of carrying creosote oil to the United States and Canada, so that during the second half of 1915 shipments to America were made in much larger volume than during the early part of the year. This information is given in a paper by G. A. Lembcke, on the "Foreign Creosote Oil Situation," delivered yesterday before the American Wood Preservers' Association at Chicago.

Mr. Lembcke states that shipments of creosote oil from the United Kingdom to the United States during the year 1915 amounted to about 35,000,000 gallons, compared with total importations of foreign creosote oils during 1914 of approximately 43,000,000 gallons, and of 55,000,000 gallons in 1913. This would tend to show that Great Britain has captured nearly the entire trade in this commodity. Moreover, Great Britain's exportations have nearly sufficed to meet the requirements, as several of the large railroad systems, on account of uncertainty of supplies, abstained during 1915 from the use of creosote oil.

Mr. Lembcke thinks that increases of British supplies will tend to offset, although not wholly so, the loss of continental quantities. He intimates that there will still be somewhat of a shortage in the supply, and that prices will remain about at the present level. He states that stocks in Germany are entirely exhausted, and that export of creosote oil from that country after the war will be very slow and greatly reduced in volume.

INSTRUCTION COURSE FOR ONTARIO ROAD SUPERINTENDENTS AND ENGINEERS.

W. A. McLean, chief engineer of highways for the province of Ontario, organized in February, 1915, a conference on highway construction for county road superintendents and engineers in Ontario. This conference was so successful that it has been decided to continue the course during the second week of February, 1916. Mr. McLean says that uniformity of methods and personal touch of the engineers of the highway department and the county superintendents, are essential for efficient work, and that these have resulted from the conference.

While designed as a means of departmental instruction to county road superintendents and engineers, an invitation is extended to all municipal engineers who may desire to attend. Each subject will be introduced by a lecture approximately one-half hour in length; to be followed by a period for discussion. The programme follows:—

Tuesday, Feb. 8th—Introductory address by the Hon. F. G. Macdiarmid, Minister of Public Works and Highways in Ontario; "Road Construction as Governed by Traffic Requirements," by R. C. Muir; "Grading," by A. H. Parker; "The Organization of a Maintenance System," by A. A. Smith; "The Administration of a County Road System," by G. C. Parker.

Wednesday, Feb. 9th—"The Use of Oil as a Dust Preventive," by W. Huber; "Painting and Maintaining Steel Highway Bridges," by George Hogarth; "Special Problems in Drainage," by M. A. Kemp; "Road Laws," by W. A. McLean.

Thursday, Feb. 10th—"Bituminous Road Construction," by R. C. Muir; "The Care of Earth Roads and the Use of the Log Drag," by W. H. Losee; "Stone for Various Types of Roads," by G. C. Parker; "Construction Methods on the Toronto-Hamilton Highway," by H. S. Van Scoyoc.

Friday, Feb. 11th—"The Care and Operation of Quarrying and Crushing Equipment," by R. M. Smith; "Resurfacing Gravel and Stone Roads," by A. A. Smith; "Concrete Bridges, Culverts and Floors," by Arthur Sedgwick; "The Operation and Care of the Roller," by W. Huber; "Maps and Plans," by T. M. DeBlois.

Chief Engineer Van Scoyoc of the Toronto-Hamilton Highway Commission, in his report on the work accomplished during the season of 1915, states that approximately seventeen miles of roadway are completed. The total length of the road is about forty miles. Grading has been finished on most of the remaining twenty-three miles.

Some delay has been caused near both the Toronto and Hamilton terminals, on account of the difficulty in coming to an agreement with the municipalities concerned on the best location of the road. There is still to be determined the gradient at which the road will enter Hamilton; also the exact location through the municipalities immediately west of Toronto.

Presuming that these matters will be decided upon before spring, it is thought that the highway can be completed by July, 1916, or earlier. The plan of the road, together with description of construction methods, appeared in *The Canadian Engineer* in the issue of July 1st, 1915.

PITCH FILLERS FOR BLOCK PAVEMENTS.

By John S. Crandell,
Of the Barrett Mfg. Co.; formerly Professor of Highway Engineering at Pennsylvania State College.

ALL pavements of the block type require some kind of filler in the joints. From time to time new materials are exploited, or new methods of using established fillers are tried. It requires time to determine whether or not a road material is successful.

For many years coal tar pitch has been the standard filler for stone block, wood block and brick pavements. Its success is undoubted, and one has but to look over the streets of any city to note how well pitch has fulfilled the function allotted to it. There are many miles of brick pavement in the middle west that were laid twenty-five to thirty years ago, with pitch filler in the joints, that to-day are in good condition. That the filler has had much to do with the life of the pavements is certain; for in the same localities are newer pavements with hard fillers that have cracked badly, or have exploded, or have become disagreeable to travel over. It is impossible to overcome natural laws, and the attempt to make a monolithic pavement which will resist expansion and contraction is an attempt to attain the impossible.

Within the past decade a method of using coal tar pitch for stone block and brick pavements has been developed that is an improvement on the older methods of filling the joints. The method originated with John Brodie, engineer for the city of Liverpool, England, and consists of making a mastic or matrix of hot sand and hot pitch in equal amounts. This is then poured or flushed into the joints.

Clean, fine sand is heated to 350° F. either at the plant or on the job. This is mixed in a 3 to 4 cubic foot batch concrete mixer with an equal quantity by volume of coal tar pitch which is brought to a temperature of about 250° to 300° F. The mixture of sand and pitch, which is called mastic, is then run into a wheelbarrow, or dump cart, and from that it is flushed over the surface of the pavement. Men quickly squeegee it into the joints, and as the mastic is very fluid, it runs into every crevice and fills every irregularity. The joints are filled to the top, and a thin coating of mastic is left on the surface. This is then covered with a light coat of screenings or torpedo sand, and traffic may be immediately admitted, or a light tandem roller may be used to roll the surface. The roller is not at all necessary.

The mixing may be done by hand if a mixer is not to be had, and the joints may be poured instead of flushing the surface. For the past two years all the new granite block pavements in the city of New York have been filled with hand-mixed mastic. The method is as follows:—

Sand is heated on the usual plate heaters on the street, and the pitch is heated in kettles or is brought to the job in tank wagons already at the right temperature. The sand and the pitch are then mixed in buckets which are especially made with a spout leading off from the bottom. The joints are then poured full of the mastic, which is allowed to settle in them. Repouring is generally then necessary in order to completely fill each joint.

A coal tar pitch conforming to the following specifications is used:—

The coal tar paving cement shall be a straight run residue obtained from the distillation of coal tar, and shall comply with the following requirements:—

1.—Melting point shall not be lower than 110° F. nor higher than 125° F.

2.—Free carbon shall not be less than 20 per cent. nor more than 35 per cent.

3.—Specific gravity at 77° F. shall not be less than 1.22 nor more than 1.30.

4.—Specific gravity of the distillate to 670° F. shall not be less than 1.06 at 140° F., compared with water at the same temperature.

The contractor before beginning work on any contract shall obtain from the engineer a statement in writing as to the melting point desired for that particular contract, and a variation of 5° F. either way will be permitted from this melting point, but within the limits as indicated above.

The kettles in which the coal tar paving cement is heated on the street shall be equipped with approved thermometers, and the paving cement shall be heated to a temperature of not less than 250° F. nor more than 300° F., and shall be poured when between these limits.

The quality of the sand is important. Based on the experience of the past three years, it would seem desirable to use sand meeting the following requirements: 100% shall pass a 10-mesh screen; not over 25% shall retain on a 40-mesh screen; not over 5% shall pass a 200-mesh screen.

Applying Mastic Filler in Granite Block Pavement at Cleveland, Ohio.

It is better to have the sand hotter than the pitch. If the pitch is too hot, the sand drops through it more readily. As is the case in all bituminous work, the materials should be dry. It is also well to have the surface of the blocks or bricks free from dirt or dust.

It has been observed in the pavements that have been laid with mastic filler during the past three years that they are noticeably quieter than those in which a hard filler is used. There are no rumbling or hollow sounds when vehicles pass over them, and horses are able to get a foothold in slippery weather. The mastic filler has been a perfect success in brick pavements laid on grades; the hot summer sun has not had any effect on it, and it has not chipped out in the winter.

One of the greatest arguments in favor of pitch filler is the fact that the pavement is ready for traffic as soon as the filler is in the joints. There is no time wasted in keeping the street closed waiting for the filler to cure. Repairs are easily and quickly made, and the repaired area can be thrown open to traffic immediately. The blocks that are removed may be relaid, for they will not be broken when openings are made in the surface.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

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for assistants to require that candidates shall be members of the Society.

A special committee, appointed by the council, has under consideration the best means of securing the appointment of engineers on civic boards, and commends the matter to the membership in general as one which is deserving of their active support.

During the past summer representations were made to the council and board of commissioners of the city of Montreal as to the advisability of obtaining a report from an independent board of engineers, upon certain proposed expenditures in connection with the aqueduct enlargement. This action of the council of the Society has received the support of the Montreal Board of Trade, but it is regretted that the Board of Commissioners did not meet the representations in the spirit that actuated the council of the Society.

The council has memorialized the Dominion Government in connection with the appointment of foreign engineers on government commissions, and has urged that inasmuch as, in some recent appointments noted, there should have been no difficulty in obtaining the services of eminently qualified Canadian engineers, it was not in the interests of the country that such appointments should be made.

The Society has been represented by delegates, specially named by the council, at the following congresses and meetings during the year: The International Engineering Congress, San Francisco; the Western Canada Irrigation Association, Bassano; the Annual Meeting of the American Institute of Mining Engineers, New York.

Treasurer's Statement.—The income of the Society for the year was $22,079.37, of which $6,732.80 was arrears of fees collected. The total expenditure during the year was $19,774.54, of which $2,266.25 consisted of rebates of fees to branch societies. The excess of receipts over expenditure for the year was $2,304.83.

The total assets are $106,432.77. There are rebates due branches and accounts payable amounting to $2,899.46, and there is cash on hand of $2,836.86. The property account stands at $89,041.64, constituting the chief asset of the Society.

Following are extracts taken from some of the committee reports that will be presented to the annual meeting:—

Committee on Conservation.

Respecting town-planning, housing and civic improvement in general, there has been in Canada, hitherto, a distinct lack of expert advice and practical guidance. Mr. Thomas Adams, late senior town-planning adviser to the Local Government Board of Great Britain and the foremost authority in his profession in the English-speaking world, has been engaged and is now advising many Canadian municipalities and civic improvement organizations. To carry out town-planning and housing projects, however, it is necessary that implementing legislation be passed. A town-planning act, drawn up with the assistance of Mr. Adams, has been passed by Nova Scotia, and a similar act is under consideration in Saskatchewan. Somewhat similar acts have been passed in New Brunswick, and Alberta, and steps are being taken to present similar legislation at the coming sessions of the Ontario, Quebec and Manitoba legislatures. Following the provisions of laws and regulations, specific projects for the various cities can be undertaken. Thus the city of St. John, N.B., is requesting authority to town-plan an area of over 20,000 acres.

A civic survey, involving an investigation of housing and economic conditions in the city of Ottawa, is now in progress. On completion of this study, a model housing act, constructed especially with a view to avoiding repetition of the evils revealed, will be prepared for submission to the legislatures, and an earnest endeavor will be made to prevent the development of conditions that make the slum possible.

Measured by tonnage, seven-eighths of the coal in Canada is in the province of Alberta. In most coal-bearing areas in Alberta and Saskatchewan the measures contain several distinct seams overlying one another and differing in thickness and quality. The operator usually selects the seam that can be worked at minimum cost, and that will give the maximum return. This seam is often mined solely with a view to the largest immediate output, the pillars are reduced to an unsafe minimum or are drawn; the overlying rocks settle, thus rendering it impossible to extract the coal they contain which is lost for ever.

Representations have been made with reference to the appointment of an officer of undoubted capacity and integrity, and with wide experience in the mining of coal, as chief inspector of mines by the Dominion Government. If appointed, this official would pass upon all plans for the development of mines under lease from the Dominion and his approval would be a necessity prior to the actual work of mining.

Committee on Portland Cement.

We transmit herewith copy of the specification for Portland cement recommended by the committee for adoption by the Society as a standard specification.

The requirements of the specification are uniform with those of the standard specification of the American Society of Civil Engineers, and the American Society for Testing Materials. The standard methods of testing as approved by the American Society of Civil Engineers are also recommended for adoption.

The specification defines a standard bag as one containing 94 lbs. net weight of cement. The present specification of our Society does not define a standard bag, but gives approximate weights per cubic foot of loosely packed and hard packed cement. Canadian cement is marketed in bags containing 87½ lbs. net weight of cement, while the United States standard bag contains 94 lbs. of cement. The committee is of the opinion that it is desirable to have uniformity in this matter with the practice in the United States of America. Accordingly, while the committee feel that the most desirable uniform unit would be a 100-lb. bag, uniform practice alone, in regard to the weight, would be a distinct gain, and a standard bag of 94 lbs. is recommended.

The question of tensile strength has received very full consideration. The present specification of our Society, and that of the American Society of Civil Engineers, demand that there shall be no retrogression in tensile strength between 7 and 28 days. In contrast with this, the British specification, for many years past, has demanded certain specified increases in tensile strength during this period, these increases depending on the strength attained at 7 days. For example, the British specification published in 1910, demanded a minimum tensile strength of 400 lbs. per sq. in. for neat cement briquettes at 7 days, and the following minimum percentages of increase in tensile strength between 7 and 28 days, namely:—

25%	if the	7-day	test	was	above	400	lbs.	and	not	above	450	lbs.
20%	"	"	"	"	"	450	"	"	"	"	500	"
15%	"	"	"	"	"	500	"	"	"	"	550	"
10%	"	"	"	"	"	550	"	"	"	"	600	"
5%	"	"	"	"	"	600	"					

Similar demands were made in the case of mortar briquettes.

This British specification has been revised recently, and in the 1915 specification the above table has been superseded. A formula, based on the actual tensile strength attained by briquettes at 7 days, has been introduced, for calculating the 28-day requirement, and the minimum tensile strength at 7 days has been raised from 400 lbs. per sq. in. to 450 lbs. per sq. in. Under the new specification, a briquette of neat cement having a tensile strength of 600 lbs. per sq. in. at 7 days, must attain a strength of 667 lbs. per sq. in. at 28 days—an increase of about 11%, as against the demand for 5% increase made in the 1910 specification. The demand for fine grinding has also been stiffened, the permissible residue on a No. 180 sieve being reduced from 18% to 14%.

The requirement of the British specification regarding increase of tensile strength is much more severe than that of the present Canadian or United States specification, which demand only that there shall be no retrogression in tensile strength during the 28-day period.

The United States Bureau of Standards has published during the past two years the results of investigations regarding the hydration of cements, and is at present conducting a series of long-period tests on the tensile and compressive strengths of cements and mortars, and the compressive strength of concretes. In this investigation several representative United States cements have been used, and have been tested, both as marketed and after finer grinding. A preliminary report of these tests, covering the period up to 180 days, has been published in the Proceedings of the American Society for Testing Materials for 1915, and the results of tests at one year, and at two later periods, will appear in due course. It appears, however, speaking generally, that while the tensile strength of the finer ground cement is higher than that of the commercial product, the rate of increase of tensile strength between 7 and 28 days, is less in the finer than in the commercial product. In some cases, the finer ground product showed retrogression in tensile strength between 7 and 28 days, although the commercial product showed an increase of tensile strength during this period. The nature of these results is directly at variance with the demand of the new British specification. The tests also show that, speaking generally, the compressive strengths of mortars and concretes made from the finer ground cements are higher than those of mortars and concretes made from the commercial product. Long-time tests alone will show whether this condition is maintained, and to what extent any retrogression in tensile strength of neat cement is reflected in the strengths of mortars and concretes.

Your committee feel that in view of all the conditions it is wiser to recommend the retention of the no retrogression demand, than to specify rates of increase of tensile strength as in the British specification. Mr. Jamieson, however, while in agreement with the draft recommended, feels very strongly that the demand of the British specification would result in an improved product, and that such a demand may yet prove to be necessary.

The question is one of considerable importance, and it appears to be only just to bring it to the notice of the membership, as many experimental investigations are in progress which will result in considerable additions to our knowledge of the behavior of cements of the present day.

Electro-Technical Commission.

This Committee begs to report that during the year 1915 the activities of the Commission have naturally been somewhat curtailed, but notwithstanding the very adverse conditions brought about by the European war, which are, of course, particularly pronounced in the case of any international body, such as this Commission is, the organization has been kept intact, a few meetings have been held, and some publications have been issued.

In March, a conference was held in London on the Rating of Electrical Machinery, this Conference being called by the British Committee of this Commission, which Committee also forms the Electrical Section of the Engineering Standards Committee of Great Britain. The American Institute of Electrical Engineers was represented by Messrs. H. M. Hobart and C. E. Skinner, Mr. A. P. Trotter, of London, England, very kindly representing the Canadian Committee, as it was found impossible to send a delegate over from this country. As a result of this Conference the above Engineering Standards Committee has just sent to press the British Standardization Rules for Electrical Machinery, copies of which will be available shortly for distribution in Canada; price to non-members, $2.50.

The International Specifications for Copper, as decided upon at the 1913 Congress in Berlin, have proved to be a great step in the work of international standardization, as was to be expected. Work on a similar specification for aluminum is about to be started, which, when finally completed, will doubtless be as valuable in its field as the corresponding work on copper.

Committee on Roads and Pavements.

The recent growth of motor vehicle traffic on the public highways has had a marked influence in two ways. It has greatly increased present and future possibilities in the use of the common roads; and in the second place, this increased traffic has increased very materially the difficulties of satisfactory road construction and maintenance.

The result has been that the construction and maintenance of roads and pavements have suddenly become of very prominent public importance. The expenditure thereon is destined to be large, and the opportunities for economy or waste are very great. In effect, this work is one to which the engineers of the country should be in a position to bring the best possible information and skill.

At the present time there are a great many new methods and materials being tested for road surfaces. This experiment is being carried on in detached sections; sometimes to a limited extent, and in other cases, following fairly accepted practice, work is in long stretches.

Under existing conditions a certain amount of co-operation among municipal engineers in supplying data associated with uniform standards of traffic would be a very valuable service. Without this co-operation, however, a large amount of useful experiment and experience is "going to waste."

The work of this Committee should extend over a series of years in order that results from all special forms of construction could be carefully watched, reported upon and the cost of maintenance determined.

It is not desirable at the present time to prepare standard specifications for roads and pavements; but consideration might be given to specifications for certain materials.

It is desired to impress, however, that there is a great waste of experience in the matter of road construction and paving at the present time due to the absence of an organization to assemble the results of such experience. It is, therefore, deemed desirable that the Committee assume this duty, and that the immediate policy should for the present include the following:—

(1) A determination of uniform traffic standards whereby wear can be more definitely compared.

(2) The compilation of the history of individual pavements. To this end, the co-operation of as many Engineers as possible through Canada should be secured, each of whom would undertake to supply from year to year definite details of a few selected pavements, showing:—

(a) Details of construction.

(b) Construction costs.

(c) Special circumstances which might influence results from the pavement.

(d) Annual costs of maintenance for a period of years.

(e) Traffic to which the road was subjected before improvement.

(f) Traffic to which the pavement is subjected from year to year.

In carrying out this work it would be expected that the history of each pavement would start on construction and would be supplied to the Secretary of the Committee annually thereafter during the life of the pavement. Should the Engineer retire from his position, it would be arranged that the duty would devolve upon his successor.

Data carefully obtained would, it is believed, have much scientific value; and the task of obtaining it should not be burdensome on either the Engineer or the municipality.

The Committee would, further, assemble the best principles of construction as followed by present practice with respect to various types of pavements, these principles to be revised from time to time as experience and further information would dictate.

Library and House Committee.

Only three books were purchased during the year; twelve were presented by members and ten by non-members. The technical magazines, transactions, etc., which have been received during the year are substantially the same as those listed in the report for 1914. They number, in all, 85. Twenty-eight are marked for binding at the end of the year, and are placed on the library shelves. The Committee has pleasure in calling the attention of members to the tablet, which has been placed on the wall of the entrance hall, in commemoration of Thomas Coltrin Keefer, C.M.G., the first President of the Society.

The Committee on Roads of the United States House of Representatives last week began consideration of a bill to provide $25,000,000 annually for co-operation between the Federal and state governments in highway construction and maintenance. It is proposed that $65,000 annually shall be allotted to each state, and that one-half of the remainder to be divided in the ratios which the population of the respective states bear to the population of the whole country, according to the last federal census, and that the other half be divided in the ratios which the mileage of rural post, free delivery and star route roads in the various states bear to the total mileage in all the states.

STREETS.*

By Geo. W. Tillson, Mem.Am.Soc.C.E.,
Consulting Engineer, New York City.

PUBLIC streets are to a city what the veins and arteries are to an individual—they provide for its circulation, and it is extremely important to all cities how their streets are laid out and improved and how maintained. Their location and condition make more of an impression upon the casual visitor than does probably any other physical thing in connection with the city, as naturally it is the one thing with which he is most connected.

The provinces of streets are to furnish light and air to the occupants and to provide proper means for interurban traffic. As regards light and air, it makes no difference how the width of the street is treated, but as regards traffic it is very material.

Light and Air.—What the width of a street should be to furnish light and air depends upon the character of the buildings that are erected upon it, and upon their height. If the street is in a residential section, where the houses are detached and built on good sized lots, sufficient light and air will be provided, no matter what the width of the street may be. If, on the contrary, the street is in a business section, where every foot of frontage is covered with buildings and where these buildings are high, the width of the street is an important consideration as regards both light and air.

Just what the relation of the width of the street to the height of buildings should be is an open question, and ordinances regulating this vary according to the ideas of the different officials; but, unless conditions specially require it, the height of a building should not be greater than the width of the street, except that when the height is greater, the front of the building should be set back a certain distance so that sufficient light and air may be furnished to the lower stories.

Traffic.—When traffic is taken into consideration, however, different principles prevail. In the first place, the width of the street must be subdivided into roadway and sidewalks, and just what shall be the relative proportions of these widths must be determined by circumstances. Different cities have different rules. An ordinance recently passed by the Board of Estimate and Apportionment, New York City, provides that the sidewalks and roadways for streets of different widths shall be as follows:—

Width of Street	Width of Roadway		
	Not Occupied by Railroad	Single-Track Railroad	Double-Track Railroad
Less than 20'	Width of Street, less space occupied by curb	Roadway occupied by a Single-Track Railroad to be not less than 30 feet	Roadway occupied by a Double-Track Railroad to be not less than 40 feet
From 20' to 50'	60 per cent		
Not less than 50' and not more than 60'	30 feet		
More than 60' and not more than 66' 8"	One-half street		
Over 66' 8"	80 per cent, less 20 feet		

*Abstract of paper read at International Engineering Congress.

(Continued on page 170.)

AERIAL CABLEWAY AT NIAGARA FALLS, ONT.

TORRES SYSTEM OF CONSTANT TENSION MULTIPLE CABLES FOR TAKING TOURISTS ON THRILLING TRIP OVER THE WHIRLPOOL — SECOND CABLEWAY OF ITS KIND IN THE WORLD AND ONLY ONE IN AMERICA.

An aerial cableway 1,800 ft. long, for transporting passengers across the Whirlpool, has been almost completed at Niagara Falls, Ont. It is the longest, and probably the safest, aerial scenic tramway in the world, and the features of its design and erection include points of engineering interest.

Guide books of Niagara Falls say that the Whirlpool seems to be a "maelstrom, a vortex of water, swirling in gradually narrowing circles to a depressed centre. Instead, the force of the water pouring into the basin, raises it in the middle to a distance of 3 ft. above the outer surface. The Whirlpool is the natural result of the mighty body of water rushing into a confined space and seeking an outlet. Bodies, driftwood, everything, in fact, that goes over the Falls must eventually find its way to the Whirlpool, where, after circling for days, perhaps, it is either thrown out upon the bank or carried by the outlet to Lake Ontario."

The Whirlpool, of which a general view is shown in Fig. 1, is about three miles below the Falls, and is almost entirely within the Province of Ontario. The cliff that encloses it is a part of the river bank on the Canadian side, so that both ends of the cableway are in Ontario, as shown in Fig. 2. But the boundary line between New York State and Ontario forms an acute angle which is intersected by the cableway about 60 ft. within the apex. The cableway, therefore, crosses a small portion of New York State. As the bed of the river is owned by the state, and the water by the federal government, the promoters had to secure permission from Washington and Albany, after they had the sanction of the Province of Ontario and of the Victoria Park Commission of Niagara Falls.

Fig. 2.—Plan of the Whirlpool and Cableway.

The design of the anchorages was governed largely by the fact that the cableway was not allowed to cross the tracks of the Niagara Belt Line Railway, and by the proper order of the park commission that the appearance of the cliffs on neither side of the Whirlpool must be altered, and that no towers or structures of any kind could rise above the level of the tracks of the railway which runs along the cliff.


Fig. 1.—The Whirlpool, Niagara Falls, Ont. Thompson's Point Across the Water, New York State at Right. Photo Taken from Colt's Point.

The design of the cableway is based upon Spanish patents, and the enterprise has been financed entirely by capitalists in Spain. The company, which has been incorporated in Canada, is called The Niagara Spanish Aerocar Co., Limited, and has issued $110,000 capital stock, $30,000 of which was granted, for patent rights, to the Society Estudios Y Obras de Ingenieria, of Bilbao, Spain, of which Jose Orbegozo, C.E., is president. The system is the invention of Torres y Quevedo, an engineer who has gained considerable European fame in aeronautics. His son, Gonzolo Torres y Polanco, C.E., is chief engineer and vice-president of the Canadian company, of which Antonio Balzola is president and secretary treasurer.

The Torres principle had been applied previously in Canada and the United States to single cables for industrial purposes, but not to multiple cables for passenger traffic.

The cost of the Niagara project was nearly $60,000, of which more than half was taken up by engineering, construction work and materials exclusive of the loading platforms and car, both of which were built in Spain. It is stated, however, that unfamiliarity with local conditions, and the fact that this is the first cableway of its kind in America—and therefore met with greater opposition from the authorities than would be the case again—account for

about a quarter of the expenditure, and that the enterprise could be duplicated for $45,000.

The passenger car is suspended from a running gear which travels on six parallel carrying, or track, cables, each of which is fastened securely at Colt's Point (see Fig. 2). At the other terminus, Thompson's Point, each track cable passes over a grooved sheave and is fastened to a counterweight or stretcher. These six counterweights are boxes 12 ft. high x 6 ft. 7 in. wide x 11 in. deep, made of riveted steel. Each box contains four cast iron pieces of 195 lbs. each and 200 pieces of 90 lbs. each, making a total load of 18,780 lbs., which, with the weight of the box itself, makes a 10-ton counterweight for each track cable. The detail of these boxes is shown in Fig. 12.

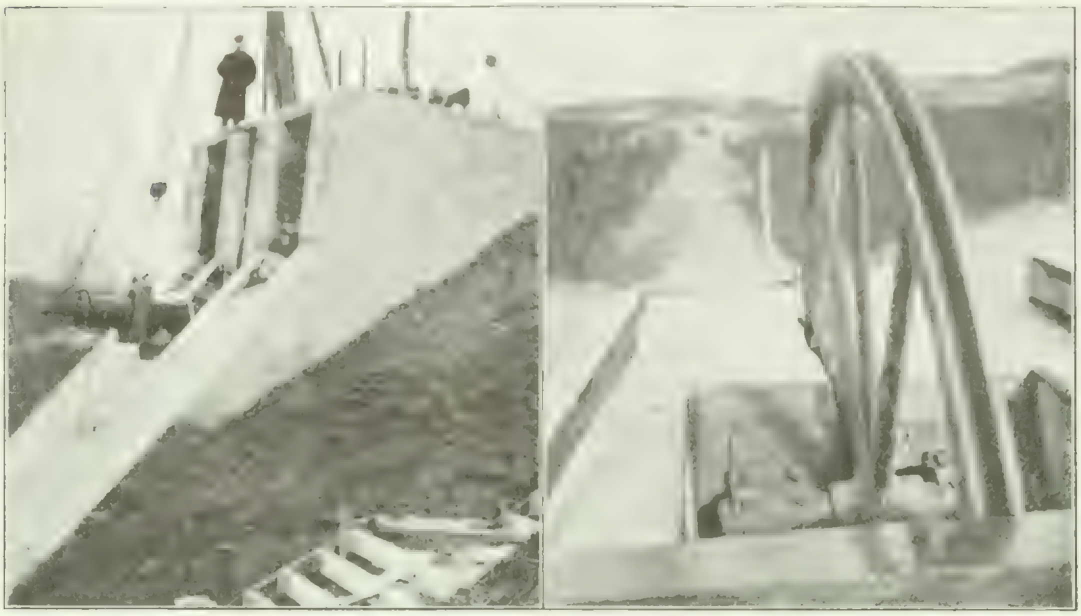


Fig. 3.—Views of Colt's Point Anchorage. At Left, the Concrete Block Before Erection of Sheave. Automatic Stop Hanging from Block and Tackle. At Right, the Traction Sheave in Place.

The boxes move up and down freely in steel guides, the details of which are shown in Fig. 10. A sudden load thrown onto the track cables would cause the boxes to rise and the cable span to sag, but the tension in each cable is always 10 tons, regardless of the load on the track cables; that is, regardless of the load on the passenger car. In other words, the tension in the track cables depends solely upon the counterweights and not at all upon the weight of passengers borne by the car. When the load on the car is increased, the counterweights rise and the sag in the cables is increased, the cables taking such an angle that the vertical components of the forces acting along them are always equivalent to the weight of the car and its load. This is disregarding the variations of tension due to the inertia of the stretchers, but they are negligible.

The track cables are 1-in. crucible steel rope, made up of seven round strands, surrounded by 16 locked coil strands. As these are too stiff to bend over the sheaves at Thompson's Point, each one is fastened, by a standard socket, 10 ft. in front of the sheave, to a 1¼-in. Monitor plow-steel cable, made up of six strands of 19 wires each, and these latter cables are bent over the sheaves and fastened to the counterweight boxes.

At Colt's Point each track cable is fastened, by a standard threaded clevis and socket, to a 2-in. rod. These six rods are bent around a concrete block weighing 741 tons, which is built into the face of the cliff, and are fastened securely at the bottom of pits which are left open to permit of inspection at any time of the nuts, washers, etc. The detail of the anchorage of these rods is shown in Figs. 4 and 9. Fig. 3 shows the concrete block.

It will be seen that each track cable is entirely independent of the others. The breaking of any one of them would not be serious, as the other cables would support all the weight of the car without any increase in their tension. The car would drop several feet suddenly, and,

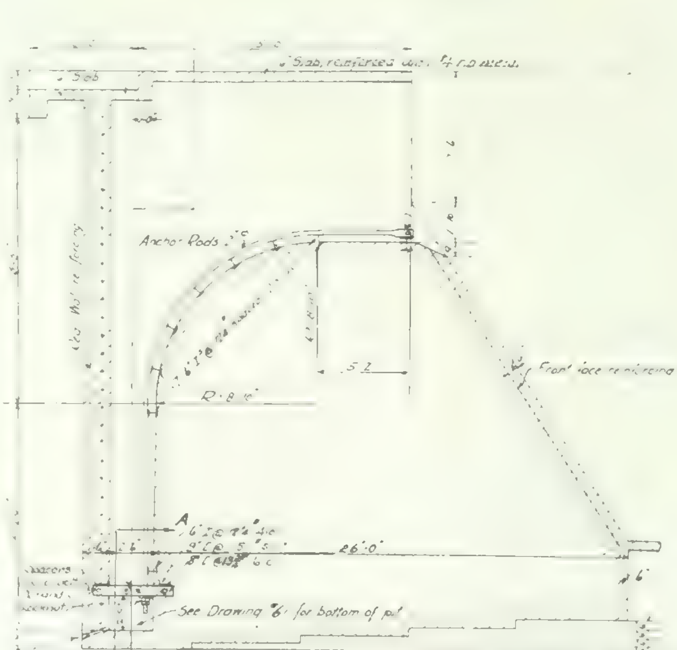
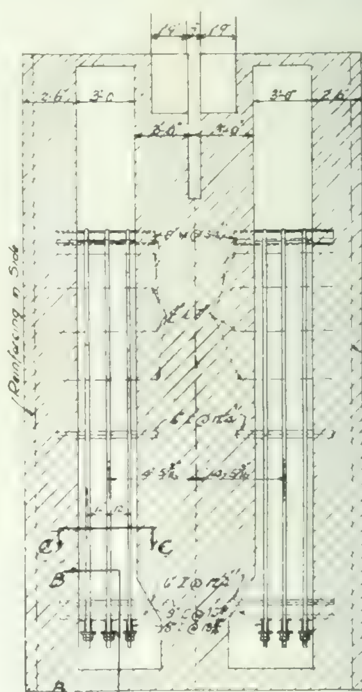


Fig. 4.—Section Through Inspection Pit.



Section 1—1.

after a few vertical oscillations, would assume a new position of equilibrium.

Thus, the breaking of one cable does not imperil the passengers, and the breaking of two cables at the same time would be nearly as improbable as the simultaneous breaking of two cables belonging to totally separate installations.

The simplicity and safety of this system lie in the fact that each cable is put into fixed tension from the start of operations, that this tension never varies, that the resistance of the cables can be verified at any time by increasing the load on the weight boxes, that if any cable or fastening is faulty it will probably break when heavily weighted for trial or inspection trips, and that if a cable does break practically no extra strain is put upon the other cables.

These facts make possible safe transportation for considerable distances, and the engineers of the company are now contemplating a mountainous installation with two spans each over a mile long. The only previous installation of this system is at San Sebastian, Spain, for transport of tourists across a gorge, from a trolley terminus to an otherwise inaccessible view-place and casino overlooking the Bay of Biscay. The span there is 919 ft. with a rise of 92 ft. It has been in successful operation for six years, carrying as many as 26,000 passengers in a single season.

The car at San Sebastian holds only 14 passengers, all standing, but the car built for Niagara provides seats for 24 passengers, and standing room, in a raised aisle in the centre of the car, for 21 more, besides the conductor. The weight of the car empty is 3½ tons, fully loaded 7 tons. It is 10 ft. 10 in. wide, 24 ft. long and 23 ft. high. It was manufactured complete in Spain, and assembled here. Fig. 7 shows the car erected on the roof of the Thompson's Point station, and carrying the test load in the form of 223 cast iron weights of 90 lbs. each, or three times its maximum passenger load. Fig. 8 shows the design of

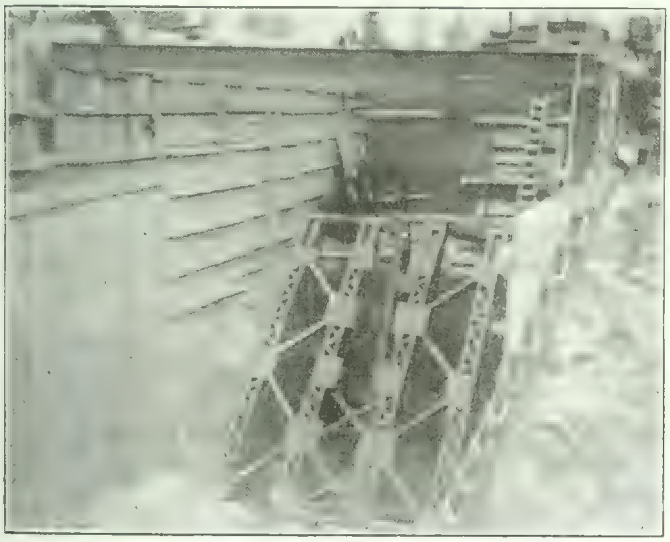


Fig. 5.—Track Sheave Towers in Place. Shaft Seen Behind Top of Tower Carries Driving Sheave in Centre, Worm Gear at Right, Relief Drum at Left.

the car. It will be noticed that should a track cable break at a point just above the car, it would most probably drop without hitting the passengers, as the carrying wheels extend beyond the basket. Besides, the frame work above the basket protects the passengers.

The car is propelled by a ⅞-in. 6 x 19 plow-steel traction cable, fastened to one end of the car. This cable passes over a sheave (see Fig. 3) on Colt's Point, runs back across the Whirlpool, over a sheave in front of the Thompson's Point station, and to the driving sheave.

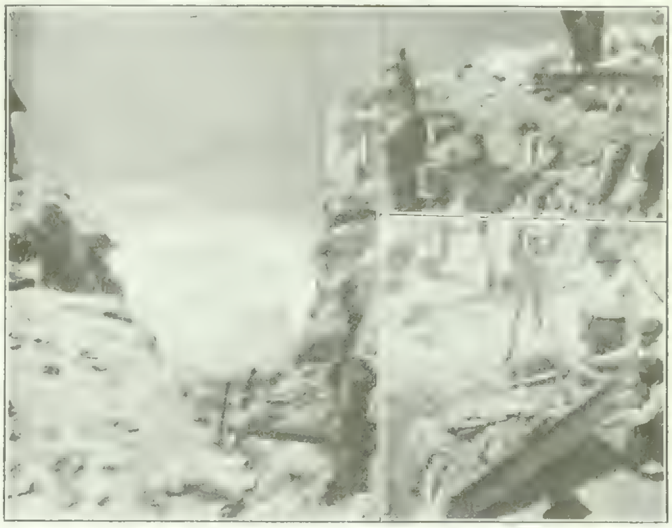


Fig. 6.—Heavy Rock Excavation at Thompson's Point. Inset Shows Method of Handling Blasted Rock.

From here it passes around three sheaves, to one of which is fastened a 10-ton counterweight box, arranged in guides similarly to the track cable counterweights, and this creates a tension in the cable which adjusts any slack caused by the rising and falling of the car. After passing around another groove in the driving sheave, the traction cable passes out to the other end of the car.

The 8-ft. driving sheave is turned by a 75-h.p., 3-phase, 440-volt, 480 r.p.m. Westinghouse motor, through a 30 to 1 Hindley worm gear, giving a speed to the car of about 400 ft. per minute when the controller is at full speed. The trip can be made in about 4½ minutes, but it is planned to permit it to occupy six minutes by running at half speed part of the time.

To provide against breakdown of the motor, or interruption in the power supply, there is a clutch in the driving shaft by means of which the motor can be disengaged, and a 5-h.p. Gray gasoline engine engaged both through a worm gear and through sprocket wheels. The speed at which the gasoline engine would haul in the car would be very slow, but it would be ample to meet the emergency.

If the traction cable were to break during a trip, the car would oscillate backwards and forwards along the track cables until it would come gently to rest at the lowest point of the sag of the cable, which would be about the centre of the span, as the two terminals are nearly at the same height, one being 249.5 ft. above the river level, and the other, 246.5 ft. To bring the car back to Thompson's Point in such an emergency, a relief car and a relief traction cable are available. Attached to the driving sheave shaft, and running idle ordinarily, there is a drum on which a ½-inch wire rope is coiled, with one end fastened permanently to the drum. After the breaking of the traction cable, the free end of the relief cable would be fastened to the relief car, a light basket which holds one man and which hangs from pulleys that can be readily thrown over two of the track cables. The driving sheave would then be reversed slowly, paying out the relief cable until the man reaches the car. After the relief

cable is fastened to the car by chains provided for the purpose, the driving sheave would haul the car back to Thompson's Point.

One thousand cubic yards of earth and 2,500 cu. yds. of rock were excavated for the two stations. The rock excavation is shown in Figs. 6 and 11. Six Ingersoll-Rand steam rock drills were used, working two drills

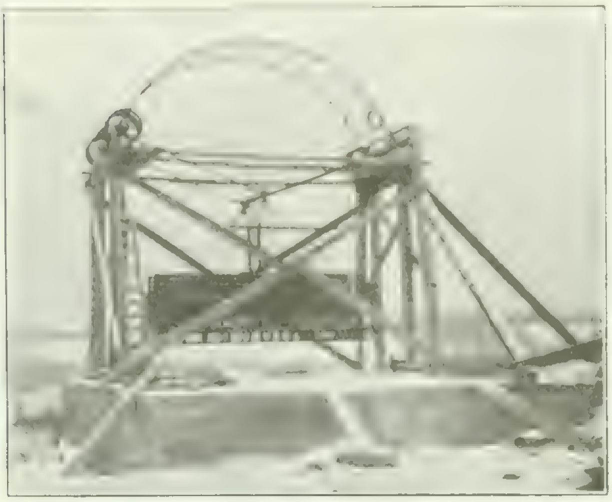


Fig. 7.—Car Erected on Roof of Thompson's Point Station, Ready for Test.

on a quarry-bar for the line drilling, as shown in Fig. 11. Rack-A-Rock explosive was used with excellent results. Colt's Point anchorage was built first, and then the construction plant was taken to Thompson's Point for the larger work. A 1 : 2 : 4 mixture was specified for the most important concrete. Canada cement and Queenston crushed stone were used. The reinforcing steel was supplied by the Trussed Concrete Steel Co. and the structural steel by McGregor & McIntyre, Limited.

The station at Thompson's Point is cut out of the solid rock and lined with concrete and buff tapestry brick. Two flights of concrete steps provide entrance to and exit from the landing platform. The station is 29 ft. 2 in. high, 66 ft. long and 37 ft. 9 in. wide over all. The roof is a 6-in. concrete slab, reinforced with rib metal, on 15-in. I-beams, placed at 5 ft. 4 in. centres. As the roof of this station is level with the ground, and makes a platform from which spectators can watch the operation of the car, it is guarded on the cliff side by a 42-in. wrought iron fence, bolted to the flange of one of the I-beams. The floor is 3 in. concrete, and the front of the station is an 18 in. rubble wall, built to match the face of the cliff. A 12 ft. x 19½ ft. opening gives access to the landing platform. The footings for the track sheave towers and for the traction sheave tower are concrete. The towers are steel. (See Fig. 5.)

At the opening of the station a horizontal steel platform, 9 ft. 10 in. long by the full width of the opening, is hinged. At the outer edge of this short platform there is hinged another platform, 38 ft. long, extending over the edge of the cliff. The latter platform is suspended from the track cables by wire ropes and pulleys at the outer corners and at the hinged corners, each rope being fastened to three pulleys, one on each of three track cables. All four ropes are of the same length, so that the long platform always hangs parallel to the track cables, whatever inclination the latter may take; the four ropes are of such length that the platform clears the bottom of the car by 6 in.; therefore, the car always comes right onto the platform. The platforms are guarded at the sides by railings.

At Colt's Point a similar landing extends from the foot of the anchorage, and two flights of concrete steps lead up to the ground level.

An automatic control stop is provided at each terminus which stops the car without jar within 3 ft. 4 in. The stop can be seen extending from the face of the

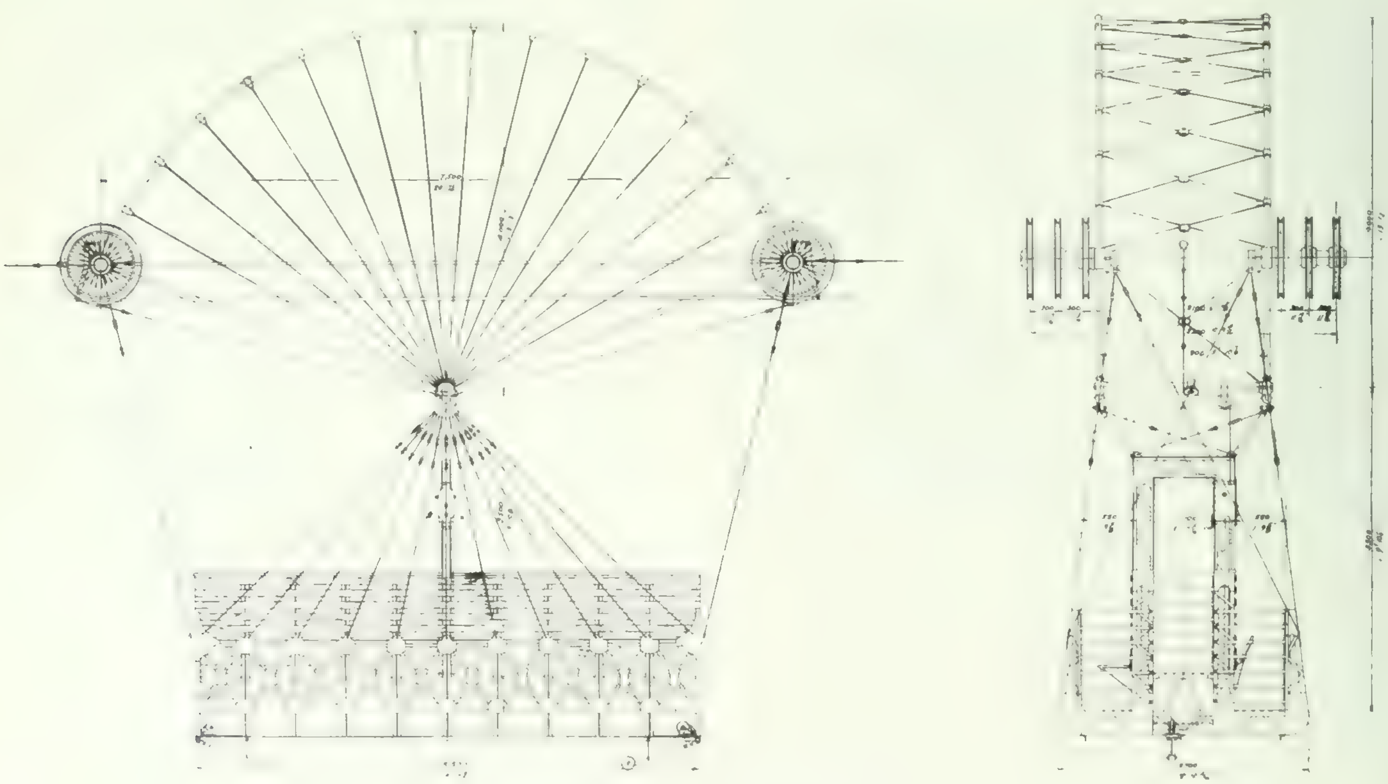


Fig. 8.—General Plan of the Spanish Aero Car.

concrete block in Fig. 3. The traction cable runs longitudinally through the 5-in. pneumatic cylinder and through the centre of the piston. A clamp on the traction cable, just ahead of the car, strikes the face of the piston, and also engages with it in such manner that the car cannot slip back from the landing platform.

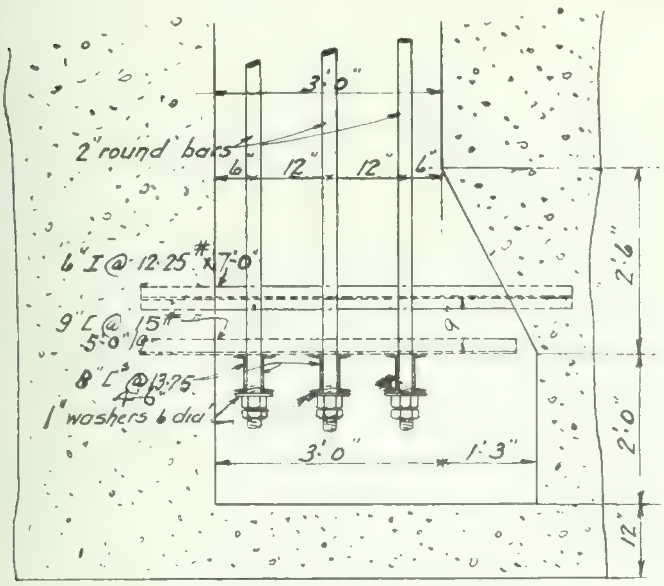


Fig. 9.—Detail of Pit Anchorage.

There are gates at both ends of the car, operated by the conductor by means of a crank, and these gates cannot open until the clamp has engaged with the stop piston, releasing a ratchet under the car. Even then, only the right gates can be opened; that is, the gates at the end of the car where the clamp has engaged. When the car starts, the clamp is disengaged by another crank, but this cannot be done until the gates are shut. This

Fig. 11.—Rock Excavation for Counterweight Pit. Inset Shows Drills on Quarry Shaft.

is contrived by interlocking discs, enclosed in a locked box on the car. The pneumatic cylinder is supported by a counterweight, so that its weight does not rest on the traction cable.

There are two limit switches at each terminus. The first is always struck by the floor of the car, and affects the controller, so that the power is turned off and cannot be turned on again in the same direction and so jam the car against the station. The second limit switch is hit only when the first fails to operate, and when the motorman fails to turn off the controller, and when the pneumatic cylinder does not bring the car to a stop. This second limit switch acts directly upon the circuit-breaker, bringing the car to rest within 3 ft., and without letting it come within dangerous distance of the station.

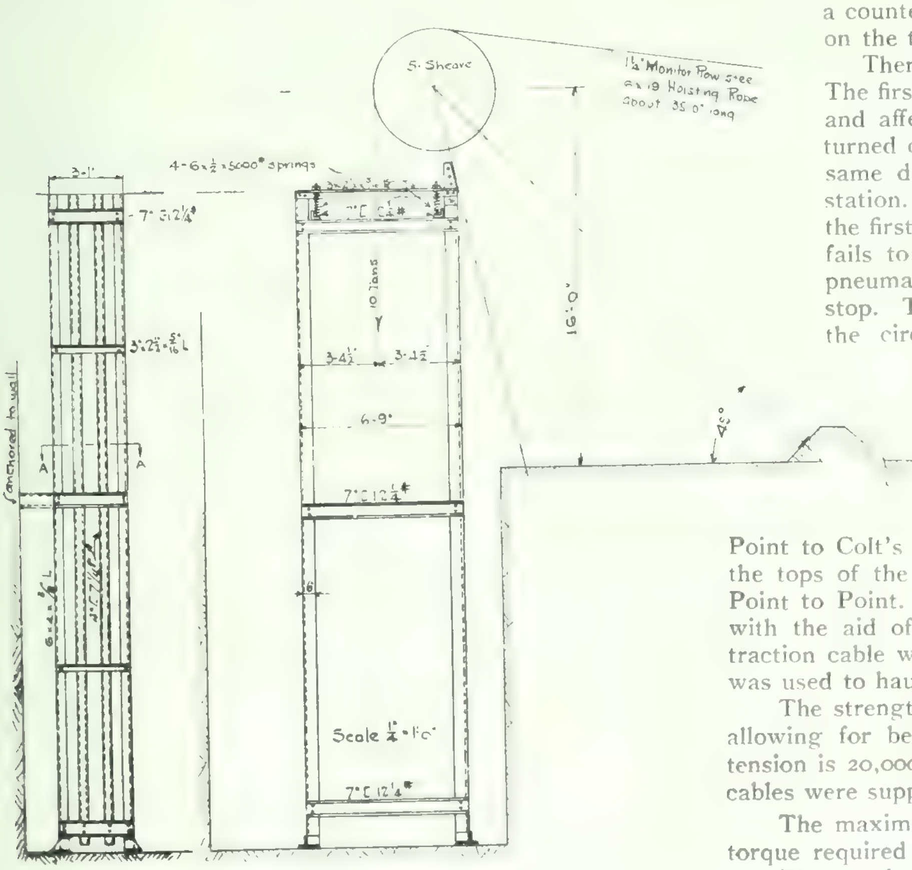


Fig. 10.—Detail of Guides for Track Cable Weight Boxes.

After the traction and track towers and sheaves had been erected, a very long rope was carried around the face of the cliff from Thompson's Point to Colt's Point. This rope was then hoisted over the tops of the trees until it could be pulled taut from Point to Point. A ½-inch wire rope was pulled across with the aid of a hoisting engine, and then the ⅞-in. traction cable was pulled into place. The traction cable was used to haul the track cables across.

The strength of the track cables is 92,000 lbs. each, allowing for bending over sheaves, and the working tension is 20,000 lbs., so the factor of safety is 4.6. The cables were supplied by the American Steel and Wire Co.

The maximum torque of the motor is 2.5 times the torque required to haul the car when fully loaded.

The maximum pull on the traction cable idler at Colt's Point is 28,000 lbs. The pull on each of the six

carrying cables is 20,000 lbs. The earth pressure is 68,300 lbs. The moment of the overturning forces about the toe of the anchorage is, therefore, 28,000 × 28.5 ft. + 120,000 × 21.5 ft. + 68,300 × 20 ft., equals 4,744,000 ft. lbs. The weight of the concrete is 1,481,800 lbs., and the resisting moment is 1,481,800 × 16.9 ft., equals 25,042,420 ft. lbs. There is, therefore, a factor of safety of over 5 in respect to the overturning of this anchorage. There is a factor of safety of about 8 at Thompson's Point.

For any position of the car, the tension in the lower traction cable between the car and the transmission sheave equals half the counterweight, or 10,000 lbs., neglecting friction of counterweight and sheaves. The tension in the remaining part of the traction cable depends on the position of the car, varying from 6,000 lbs. when the car is at Thompson's Point to 14,000 lbs. when the car is at Colt's Point. The traction cable has

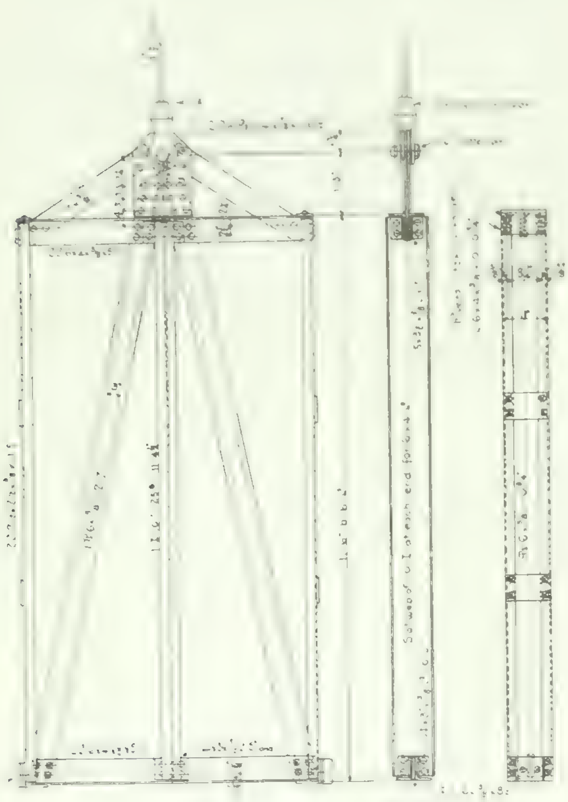


Fig. 12.—Detail of 10-ton Weight Box for Track Cable.

a strength of 70,000 lbs., so this allows a factor of safety of more than 4, after deducting from strength of cable for bending over sheaves.

The sag of the track cables unloaded is 47.6 ft. The maximum sag when loaded with car and passengers is 100.1 ft. The car will still be 148 ft. above the surface of the water at the point of maximum sag.

The maximum vertical travel of the track weight boxes, allowing for change in length of cables due to 125° variation in temperature, and due to difference in deflections, is 11 ft. 2 in. The possible vertical travel is about 19 ft., thus providing for oscillations due to breaks of cable.

The maximum vertical travel of the traction cable counterweight is 8 ft. 8 in. The possible travel is 15 ft.

The grade of the track cables varies from 16 per cent. at either landing to 0.0 per cent. at the centre of span. The maximum grade, therefore, is 16 per cent., and the average grade about 8 per cent.

Work was started July 12, 1915. All cables are now erected and the car is being put in place ready for the trial trip, which will be made with the test load of 10 tons. The cableway will be ready for regular traffic within a few weeks. The amount of the fare to be charged passengers has not yet been decided upon. The park commission collects an annual rental which increases with the number of passengers carried, besides a minimum rental of $3,000 a year.

The general contractors for the complete installation were Norman McLeod, Limited, Toronto, on a cost plus percentage basis. The superintendent in charge of construction was Lewis S. Roy. J. E. Taylor was resident engineer, representing Wright & Howard, consulting engineers, Toronto, who were employed by the Spanish company to adapt their design to local conditions, and who prepared the plans and supervised the construction. The work is to be to the satisfaction of the Hon. F. G. Macdiarmid, minister of public works of the province, who entrusted direct supervision to Geo. Hogarth, A.M. Can.Soc.C.E., assistant engineer of his department.

To all of the above mentioned firms and individuals, *The Canadian Engineer* is indebted for the information in this article.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The annual meeting of the Toronto branch of the Canadian Society of Civil Engineers was held last Friday night at the Engineers' Club, Toronto. G. A. McCarthy, engineer of railways and bridges of the city of Toronto, was elected to succeed J. R. W. Ambrose as chairman. Prof. L. M. Arkley, of the University of Toronto, was elected secretary-treasurer to succeed C. H. R. Fuller. The executive committee elected for the following year consists of E. W. Oliver, A. H. Harkness, A. L. Mudge and H. G. Acres.

Nine meetings were held during the year. The membership is now 344, compared with 295 at the end of 1914. The annual excursion of the branch took place on November 5th, and consisted of a tour of inspection of the Welland Ship Canal. The death of R. Sherwood Elmsley, who was a member of the branch, is reported as having occurred during the year. The financial statement for the year shows that the branch is in fair condition. During the year, standing committees were formed to study in co-operation with those formed by the parent society. The members of these Toronto committees are:—

General Clauses—W. Chipman, chairman; E. W. Oliver; E. L. Cousins; Wm. Cross; David Molitor.

Portland Cement—A. W. Connor, chairman; G. A. McCarthy; G. G. Powell.

Reinforced Concrete—Prof. Peter Gillespie, chairman; Frank Barber; A. L. McAllister; David Molitor.

Relation of the Engineer to the Public—E. W. Oliver, chairman; Prof. H. T. Haultain; Henry McAll.

Roads and Pavements—W. A. McLean, chairman; W. Huber; H. S. Van Scoyoc; E. A. James; M. A. Stewart; S. J. Tolman.

Steel Bridges—A. H. Harkness, chairman; C. S. Rogers; H. L. Steenbuch; C. R. Young.

Hydraulics—N. R. Gibson, chairman; T. H. Hogg; H. G. Acres; E. C. Dowson; G. Milne; Wm. Cross.

Power Plant—Prof. L. M. Arkley, chairman; Jas. Milne; A. L. Mudge; E. T. Brandon.

Sewage Disposal—Andrew Macallum, chairman; E. R. Gray; Peter Gillespie; W. Chipman; F. W. Thorold; I. H. Nevitt.

Editorial

THE PRESENT STATUS OF HYDRO-ELECTRIC POWER PLANT PRACTICE.

Marked improvement is apparent in present-day hydraulic power plant practice over that of ten years ago. The change is along many lines, and its results are shown in the higher turbine efficiencies obtained, the use of larger units, the increase in the comparative capacities of runners, and the tendency towards elimination of complicated mechanisms.

The improvement in the individual efficiencies of turbine runners has been obtained by changes in the runner designs themselves and by the method of setting. Efficiencies of 92 and 93 per cent. are shown under Holyoke tests, on test runners, and on the installed runners under conditions of service. Efficiencies of 90 per cent. are quite common now, as compared with 75 to 80 per cent. a few years ago.

A greater flexibility in the commercial design of runners is to be noted. To-day it is quite possible to obtain reaction runners with specific speeds from as low as 10 to as high as 115, and for conditions of service from 6 feet head to 600 feet.

For low-head work, a radical change has taken place in the design of runners. The use of wider, deeper and fewer buckets has resulted in a remarkable increase in the specific power and speed. Recent designs, such as the Cedars Rapids and the Keokuk runners, show a capacity about twenty times as great as the original Francis turbine of 1849.

For high-head work, the development of the low specific runner has allowed the use of the Francis runner in place of the impulse wheel for developments such as Eugenia Falls, where a specific speed of 16 is used for a 2,200-h.p. runner under 540 feet head.

The capacity of individual runners has greatly increased, due partly to improved methods of setting. The vertical type unit in the past has not been favorably received by engineers, due to troubles arising from thrust bearings. However, there are now at least three satisfactory types of these bearings. This has allowed the use of much larger capacities concentrated in a single runner, and as a result has facilitated the use of large scroll cases and draft tubes molded in the concrete substructure, increasing greatly the overall efficiency of the unit. Capacities of 20,000 h.p. in a single runner have already been obtained, and prospective developments within the next year are likely to more than double this figure.

Speed regulation is being given more attention now, and the theory of design in this branch has kept pace with commercial practice. By the judicious addition of weight in the rotor of the generator or the use of a fly-wheel, by a careful study of the proper velocities in the feeder conduits, by the installation of surge tanks, and the proper time of governor setting, and by improvements in the governors themselves, together with the use of pressure regulators, the old troubles of regulation and governing are well under control.

It is unlikely that there will be much further improvement in efficiencies of the runners themselves. Improvements will be confined to the layouts of the plants in which the units are placed, to secure simplicity of operation and to reduce maintenance charges.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

For the thirtieth time, the Canadian Society of Civil Engineers next week will assemble in annual convention. Every member owes it to himself and to his profession to be present if possible. Each engineer will likely be benefited by the Society exactly to the extent that he benefits the Society. What he will "get out" of the Society depends on what he puts into it. The law of compensation is certain and inevitable.

Important legislation is pending; the term "civil engineer" will be defined; the profession will likely be made a closed one very soon; matters of ethics are to be settled; the West and the East must be brought into greater harmony; in short, much will develop during the course of next week's meeting which will make it well worth while for every member to spend January 25th, 26th and 27th in Montreal.

THE WESTERN CANADA POWER COMPANY.

The members of the Canadian Society of Civil Engineers who had the pleasure of hearing the very complete paper descriptive of the Stave Falls plant, read last October at Montreal by R. F. Hayward, chief engineer of the Western Canada Power Co., have learned with much regret of the concern's inability to meet the interest on its first mortgage bond issue, which is between five and six million dollars. Undoubtedly the default is largely accounted for by the fact that the plant, property, franchises, transmission lines, substations, etc., cost $400 per h.p. of present output. It is suggested that additional units be installed to increase the capacity to 52,000 h.p.

There is not the market in the Vancouver district at the present time, however, for an increased power output, and the company would not seem to be well advised in increasing its capacity at this time. As a matter of fact, the Western Canada Power Co., and all of the other companies near Vancouver, have now a surplus of power. The load of the B.C. Electric Co., which is the chief customer of the Western Canada Power Co., has dropped to where is was in 1912. The Western Canada Power Co. now has two 13,000-h.p. units. The B.C. Electric Co. are taking about 10,000 h.p., and Stone & Webster interests are said to be taking about 5,000 h.p., but it is undoubtedly proving difficult to market the remainder of the present capacity. The Heaps Co. and some of the other big lumber firms which formerly were good customers, have shut down to a considerable extent. Ultimately, the Vancouver district will be able to take all of the power produced by the Western Canada Power Co. and the other companies now operating in that vicinity, but not for some years to come.

It is unfortunate that two more 13,000-h.p. units have already been constructed for the company and have probably been held by their builders for some time awaiting acceptance. Two generators are in the shops of the C.G.E. at Peterborough. One Escher-Wyss turbine is in customs at Vancouver, and another at their works in Zurich. It will cost $625,000 to instal these units and to complete the dams necessary for their operation to full capacity. The wisdom of spending this money at present is to be doubted in view of the state of the power market.

Canada has wonderful water powers which it will be profitable to develop, but after the Western Canada Power incident, capital will undoubtedly fight shy of too heavy expenditures per horse-power of marketable output.

IMPORTANCE OF RADIAL ELECTRIC RAILWAYS.*

This report provides for the construction of entrances for high-speed radial electric railways, with complete grade separation, and terminal in the downtown district, giving ideal conditions for efficient operation.

The Hydro-Electric Power Commission of Ontario, on the request of 300 municipalities in Western Ontario, is preparing estimates, and will submit reports, upon the construction of radial electric railways, of which Toronto forms an important terminal. Fifteen hundred miles of line have been surveyed, for cost of construction and traffic, and during the coming year, reports will be completed on 300 miles of line. A comparison of the existing purported radial service of the city of Toronto with that of other municipalities, discloses the fact that Toronto does not possess radial service. This is illustrated by the following table:—

Radial Railways Entering Municipalities and Their Relation to Population.

		Average population per mile		
District.	Route miles.	Rural.	Urban.	Total.
Milwaukee	448	131	1,240	1,371
Detroit	793	129	352	481
Cleveland	515	264	744	1,008
Boston	1,453	2,190	1,023	3,213
Toronto	82	271	473	744

Radial Electric Railways Within 25 miles of Central Municipalities for Years 1910-1911.

District.	Miles of Line.	—Population per mile— Civic.	Adjacent.	Total.
Toronto	60	5,462	2,132	7,594
Indianapolis	310	754	445	1,199
Dayton	254	259	705	1,164
Cleveland	217	2,584	961	3,542
Toledo	250	674	443	1,126
Milwaukee	165	2,264	1,280	3,546
Boston	762	880	1,762	2,641
Detroit	187	2,491	775	3,245
Cincinnati	226	1,608	2,537	4,146

The development of long distance transmission of power, and improvement in the art of electric traction, have made possible the construction and efficient operation of radial electric railways, between centres of population, filling in the gaps between surface street railways, rapid transit systems, and rural highway lines on the one hand, and steam roads on the other, offering many advantages to the districts through which they are constructed, some of which are as follows:—

Influence on the Evolution of Large Cities.—A high-speed electric radial railway enables suburban and rural districts adjacent to large cities, to be measured in terms of time rather than distance, and makes these districts accessible for daily passengers to and from commercial centres.

The construction of radial electric railways with their improved service at lower rates increases the riding habit of residents in rural and suburban districts, and augments travel between these districts and the centres of population.

*From Toronto Civic Rapid Transit Report.

The following table illustrates the marked increase of the riding habit in a few of the many districts in the United States as compared with steam service:—

	Passenger rides per day Steam.	Electric
Ann Arbor and Detroit	200	4,000
New Britain and Hartford	400	2,000
Cleveland and Lorain	116	8,493

Improved Social Conditions.—The radial electric line enables the wage-earner, and others of limited means, to possess in the suburban and outlying districts, more commodious homes, and greater opportunities for outdoor recreation. It also enables dwellers in the congested city districts to travel to the country with convenience, speed, and at low rates. Statistics show that in the cases of the large European and American cities, about four-fifths of the workmen travel at least 7½ miles to their places of employment, and the remaining fifth, from twenty to twenty-five miles, with a limit of about one hour of travel each way. The rapid and more frequent service encourages travel, from rural and suburban districts to the cities, for business and amusement.

Improved Market Conditions.—By providing an efficient and rapid service, at reasonable rates, the radial electric railway effects an improvement in market conditions, and facilitates the handling of foodstuffs by expediting transfer from producer to consumer. Frequent express service, at freight rates, with convenient stops, enables merchants to supply their customers in suburban and rural districts, promptly, with fresh material and with a corresponding reduction in dead stock carried.

The Chicago Municipal Markets Commission, reporting in 1914, states that "trolley freight service with its cheap rates and practically house to house collection of farm products should be of enduring interest to the city consumer and to the producer."

General merchants from thirty-nine towns in Eastern United States, reporting to the Census Bureau in 1907, were unanimous in stating that the net result of their business has been increased. Those towns adjacent to large cities such as Cleveland, Chicago and Detroit, found that whatever business was lost to those cities was more than made up by the gain to smaller places. In practically every case, increased business was done with the farmers, and most of the merchants were of the opinion that electric lines were of benefit to them.

Speed of Operation.—Following is a schedule of speeds on various radial electric railways operating in the United States:—

	Distance, miles.	Speed, miles per hour.
Detroit United Ry.—Detroit to Toledo.	60	30
Detroit United Ry.—Detroit to Jackson	76	26
Michigan United Ry.—Jackson to Kalamazoo	68.4	28
Aurora, Elgin & Chicago Ry.—Chicago to Glen Ellen	23	30.5
Aurora, Elgin & Chicago Ry.—Glen Ellen to Elgin	18.5	41
Chicago, Lake Shore & South Bend Ry. South Bend to Pullman	76	21
Evansville Ry. Co.—Evansville to Rockport	20.73	24.8

The Montreal Tramways Co. announces that the company's steam plant on Notre Dame St. East, will be enlarged by 50,000 h.p. to 60,000 h.p. The present capacity is 10,000 h.p. The first unit will be proceeded with this season.

WOODS SUITABLE FOR CROSS-TIES.*

By R. Van Metre,
of Joyce-Watkins Co., Wood Preservers, Chicago, Ill.

A LIST of woods suitable for cross-ties might fairly embrace, with few exceptions, every species that grows in commercial quantities. One group consists of the woods that are generally recognized as being sufficiently durable without preservative treatment, and includes the white oaks, black locust, walnut and cherry, sassafras, mulberry, chestnut, cedar, heart longleaf pine and bald cypress. To this list some railroads add all red gum and all red beech. Other roads eliminate certain minor species and include them in the group acceptable for treatment.

The other group consists of the woods requiring preservative treatment, and this group is worthy of constant study, for from it will come the future tie supply. In this group may be included, with few exceptions, every species that grows in commercial quantities, as before stated.

In considering the value of any species for a tie, aside from the natural durability and its capacity for treatment, there are three points of importance:—

1. That it be sufficiently strong to withstand the ordinary strains due to centre binding, etc.

2. That it be sufficiently dense to resist spike-pulling and lateral pressure on spikes; and

3. That it be sufficiently hard to have a proper resistance to rail wear.

It is desirable that some classification of the mechanical suitability of the different species as ties be established from a comparison of their mechanical properties. The Forest Products Laboratory has been working on this, and has suggested the practicability of basing a classification upon a composite figure involving the following mechanical properties:—

1. Static bending: (*a*) Modulus of rupture. (*b*) Fibre stress at elastic limit.

2. Impact bending: (*a*) Fibre stress at elastic limit.

3. Compression parallel to grain: (*a*) Maximum crushing strength. (*b*) Fibre stress at elastic limit.

4. Compression perpendicular to grain: (*a*) Fibre stress at elastic limit.

5. Hardness: (*a*) End hardness. (*b*) Side hardness.

Such a method, using the results secured in the many thousands of tests conducted at the Laboratory on small, clear specimens, and combining the data on a basis which would seem to give to the different properties a proper and reasonable weight in the composite figure, would result in the following classification of some well-known species:—

Timbers Arranged in Order of Their Mechanical Value as Ties.

Species.	Average Composite Value.
Black locust	1666
Sugar maple	1140
White oak	1050
Red oak	972
Beech	955
Longleaf pine	914
Red gum	825
Shortleaf pine	800
Western larch	790
Tamarack	740
Eastern hemlock	700
White fir	610
Lodgepole pine	590
Western yellow pine	560
Northern white cedar	420

In using such a classification, the variability of timber must always be considered, since the strength of any given species may vary widely. The figures given are for average forest-grown material, and individual pieces of any of the species may vary as much as 30 per cent. above or below the average.

The idea of attempting to develop a standard table of this kind, based on a large number of mechanical tests, is worthy of careful consideration. It can be enlarged to include every species which is available in sufficient quantities, and the writer believes would be of considerable value to anyone facing the situation caused by the decreasing supply of the oaks.

In addition to the mechanical properties, an important factor in determining the suitability of any species as tie material, is the question of how a wood undergoes seasoning.

A few years ago the specifications of many of the roads required that ties be winter-cut—between October 1st and March 1st—but in most cases this requirement has been eliminated or entirely ignored. The writer believes if that requirement had been rigidly insisted on, with regard to the so-called softwoods, such truly serviceable woods as beech, gum, the maples, birch and elm, would be standing favorably with the red oak group, instead of having yet to prove their merit. Summer-cut ties of these species are subject to the severe checking and deterioration by incipient decay before treatment that winter-cut ties escape to a great extent.

The solution of the problem of handling these softwoods is simple in theory, though more difficult in practical operation. It requires two things: Rigid restriction of the cutting period to the months between October 1st and March 1st, and the proper piling of ties for seasoning at every stage from the woods to river bank or right-of-way to the treating plant yard. Unfavorable results from treated ties made of these woods can usually be traced to failure to observe these precautions.

It is generally conceded that red oak is the very best wood for ties. It is strong, easy to treat, easy to handle to avoid deterioration before treatment, hard to resist rail-cutting and spike-pulling. For these reasons, all concerned would gladly limit their operations in treatment ties to this wood if there were sufficient timber available to supply the demand. But the red oaks for ties are fast going the way of the white oaks. The so-called inferior woods must make up the shortage, and of these, the timber supply and rate of growth will take care of the demand for many years.

It is not too early to begin to conserve the supply of red oaks for future use in track where the service is severe. This can be accomplished by letting down the bars to other woods on their merits as proved in the test tracks maintained by most large roads that are most earnest in efforts to determine each wood's value.

It is only a matter of time when every wood having the requisite mechanical properties will be used for ties. That time will come when the producers and consumers of ties co-operate to control the period of cutting and method of seasoning, so that ties will reach the treating plant with their natural condition unimpaired.

*Paper read to-day before American Wood Preservers' Association at Chicago

STREETS.

(Continued from page [illegible].)

This ordinance is not absolute, that is, it can be varied at any time according to the demands of any particular street, and is so varied whenever occasion requires.

As a general proposition, a street in a wholesale district is not a thoroughfare, and a roadway width that will fill local requirements is ordinarily sufficient. On the other hand, such a street is also little used by pedestrians, so that a wide sidewalk is not necessary; in fact, it is even objectionable, as in most cases goods have to be taken across the sidewalk from the truck to the building or from the building to the truck, and therefore a walk should be no wider than is absolutely necessary. If, then, a minimum width of a wholesale street is taken as 60 feet, the question is to divide this width so that it will be best adapted for the traffic.

But one row of trucks can be loaded in front of any building at one time. Large trucks, in Manhattan, New York City, backed up against the curb occupy 13½ feet. If the opposite side of the roadway be similarly used, 27 feet in all will be blocked to transient travel on the street. If the roadway of the street be made 40 feet wide, there will be an unoccupied space in the centre of 13 feet, which would allow trucks going in opposite directions to pass without any difficulty. It, too, would leave sidewalks 10 feet wide, which would be amply sufficient for pedestrian travel. This reasoning is based on the supposition that there will be no encroachment whatever beyond the building line and that the entire sidewalk space will be free and clear.

On retail business streets different conditions govern, as pedestrian traffic is much greater, compared to vehicular traffic, than on wholesale streets. Fifth Avenue, Manhattan, New York City, is without question the greatest retail business street in the country, if not in the world. Its entire width is 100 feet, and this width, in the business part of the borough, until a few years ago was subdivided into two sidewalk spaces of 30 feet each and a roadway of 40 feet. The property owners, however, had been allowed to use the sidewalk space to within 15 feet of the roadway, so that a space of 15 feet on each side was all that was really allowed for pedestrian traffic. In 1909, a movement was begun to widen the roadway and remove the encroachments on the street. The curb was set back 7½ feet on each side and all projections removed beyond 2½ feet from the building line, so that there were obtained a roadway width of 55 feet and a sidewalk space of 20 feet on each side for pedestrians. This provided for three lines of traffic on each side of the street, where before there was room for only two, and 20-ft. sidewalks were provided for pedestrians in place of 15-ft. sidewalks. This improvement has been carried out from 26th street to 58th street, which is the larger part of the business section of the street.

On residential streets the questions that have been discussed are determined more by sentimental than by utilitarian principles, as a great deal depends upon whether the lots are built up solidly, as in our cities, or whether the houses are detached. Where they are built up solidly, the rule in force in the city of New York at the present time, giving a roadway width of 30 feet and sidewalk spaces of 15 feet for a 60-ft. street, is probably as satisfactory as can be obtained. In outlying sections, however, where the houses are detached, it is possible to reduce the roadway to 24 feet where traffic is only local, and the width of the sidewalk itself can be a smaller portion of the sidewalk space, that is, 6 or 8 feet wide, according to the requirements of the street; the remaining space can be sodded and allowed for the planting of trees or shrubs. If car tracks exist on the street, however, the principles governing are different, and probably the arbitrary ruling of the Board of Estimate and Apportionment, New York City, providing for a 40-ft. roadway, is satisfactory. If a street is so narrow that it will not admit of a 40-ft. roadway, but one track should be allowed on the same, with one-way traffic, the return traffic being provided for on an adjacent street.

A striking example of special treatment is shown in the case of Queens Boulevard, Borough of Queens, New York City. This boulevard is 200 feet wide, and extends from the centre of Long Island City southeasterly towards the Rockaways. It is proposed to provide a space for rapid transit and surface railroads. The arrangement makes provision for a central space 74 feet wide for the use of these roads and for roadways 43 feet wide on each side of this central space, the remaining width of 40 feet being assigned to sidewalk spaces, each to have a width of 20 feet. Another section of the boulevard, where there are no tracks, provides for a central portion 44 feet wide, with adjoining 30-ft. park spaces on each side, two roadways 28 feet wide, and sidewalks of 20 ft.

Grades.—The question of grades of streets is extremely important, and great care must be used in establishing them. Maximum and minimum grades should be adopted for general guidance, to be varied only in extreme cases. Before the days of the cable and electric cars the maximum grade in a street-car street was determined by the ability of the horses to draw a car up a hill. That was, in some cases, decided to be 5 per cent. The advent of the different powers, however, in street-car work has changed this principle, as the trolley cars easily negotiate a 10 per cent. grade, and cable cars even steeper ones, but it would seem that 10 per cent. is a maximum limit, unless very exceptional conditions are encountered. As a minimum, 0.5 per cent. is a good standard, but that can be reduced to 0.25 per cent. on special streets and for short distances.

New York City has grades on business streets as high as 6 or 7 per cent., but they are extremely objectionable for vehicular traffic and should be allowed only where necessary. On some streets in the Borough of Manhattan, New York City, there exist grades of 12 and 15 per cent., and one of 18 per cent. In a report made in 1898 a consulting engineer of New York City, in speaking of this question, said: "But the City of New York has apparently adopted a maximum grade for its thoroughfares of 18 per cent."

Duluth has grades of 12.2 per cent.; Kansas City, of 16.5 per cent.; Pittsburgh, of 17 per cent., and one for an extremely short distance, some time ago, as high as 30 per cent. But probably the city that has the steepest grades in the world is San Francisco, where one street has a grade for about a block of 55.5 per cent., and Kearney street, in the thickly populated section of the city, has a grade of practically 30 per cent.; and there are many paved streets in the city with grades that exceed 20 per cent.

Streets with such grades, of course, cannot be used to any extent. An ordinary staircase has an inclination of about 64 per cent., so one can easily understand what these excessive grades mean.

Treatment of Roadway.—Having determined upon the width of the roadway and the grade of the street, the next thing to determine is the treatment of the roadway. For hundreds of years pavements have been laid of different materials and many experiments made to determine

which made the best pavement. In the making of these experiments, pavements have been laid of asphalt, coal tar, cement, iron, brick, rubber, shells, gravel, iron slag, and even leather, glass and hay; but at the present time the standard pavements are laid with stone blocks, brick, wood blocks, asphalt and other bitumens.

Just what particular material shall be used upon any street is a question to be decided only after careful study and reflection, as one must know not only the requirements of the street itself, its users and those doing business upon it, but the character of the different paving materials. Not enough study has been given in this country to this question, and pavements, as a rule, have been arbitrarily laid of certain materials without any scientific determination.

Foundation.—No matter what the character of the pavement, it is absolutely necessary that it be laid upon a solid foundation. It has generally been accepted by engineers that concrete makes the best foundation, as a general proposition. The materials for it can be obtained at reasonable prices anywhere that pavements are required, and for that reason it is almost always used for pavement foundations. The common practice is to mix the concrete in the proportion of one part of cement to three parts of sand and six parts of broken stone of a size ranging from 2 inches downward. The thickness to which it shall be laid depends upon the character of the traffic on the street, but, as a general proposition, 6 inches has been accepted as the right depth, but in special cases it has been laid 8, or even 10, inches deep.

In the city of Glasgow, Scotland, however, where loads weighing one hundred tons are moved along the streets, the foundations are only 6 inches thick. The mixture, however, is 1:2:4, instead of the 1:3:6 previously given.

Sidewalks.—Sidewalks are constructed of stone, cement, and brick, according to the availability of the different materials, and the cost varies in accordance with the distance the material has to be transported.

When sidewalks are not laid for the full width of the sidewalk space, as often occurs in residential districts, the question comes up as to whether it should be laid next to the curb or some distance back from it. If there is left a space of three or four feet between the outer edge of the walk and the curb, this can be sodded and used for planting trees. On the other hand, in the winter, when snow is on the ground, as the snow melts the water runs to the walk from both sides. If the walk is placed next to the curb, when cleaned of snow the water comes only from one side, and then flows freely to the gutter.

In cities where there is but a light snow fall, if sidewalks are only 5 feet wide, probably the best results will be obtained by laying the outside edges some three or four feet back from the curb.

In most American cities it has been the practice to allow property owners, in the business section of the city, to construct vaults under the sidewalk space out to the curb line, and sometimes even beyond. This is a practice which is not advisable. The street belongs to the public from property line to property line, and should be reserved to the public for its use. In modern times, when so many public utilities are placed underground, it would seem that the sidewalk space should be used for this purpose wherever possible. In foreign cities it is the practice to lay the sewer and the large water and gas mains in the roadway, but, wherever possible, to lay the others under the sidewalks. In this country, however, that practice has been followed to but a very slight extent, although at the present time the feeling in New York City is that it is advisable to do this.

The one thing which causes the most damage to American pavements is the constant disturbance by digging in the streets for the construction or repair of these underground utilities, and anything that will reduce this work will not only add to the life of the pavement, but materially reduce the cost of repairs. In many cases it will doubtless necessitate the construction of two lines for each utility in the street, but the connections to the property will be so much shorter and the cost of repairs so much less that undoubtedly it will be an economical proposition in the end. It may be somewhat difficult to bring this about in the business part of the cities where the utilities are already constructed under the roadways and vaults exist under the sidewalks, but in the outlying districts it is not only practicable but advisable to place these utilities in the sidewalk area.

COAST TO COAST

Saanich, B.C.—Last year the municipality of South Saanich spent $145,000 on roads.

Ottawa, Ont.—In Canada there are projected at the present time 375 miles of railway lines, and there are 299 miles under survey and 578 miles under construction.

New Westminster, B.C.—The city has laid approximately ten miles of pavement since the inauguration of a street improvement campaign in 1910.

Quebec, Que.—During the past year 436.30 miles of road were constructed in the province of Quebec, 295.60 miles of which were macadam. Since 1911 there have been constructed 1,667.67 miles of road.

Vancouver, B.C.—The extension of the Pacific Great Eastern Railway to Clinton, 47 miles in length, has been completed and put into operation. The P.G.E. has now in operation 166 miles of its line from Howe Sound northwards.

Three Rivers, Que.—The Three Rivers Traction Co., which inaugurated their city line here on December 11th, recently opened the extension line to Baptist Island, where the mills of the Wayagamack Pulp and Paper Co. are situated.

South Vancouver, B.C.—According to a statement prepared by Municipal Engineer S. B. Bennett, the construction of the municipal sewerage system has so far cost $110,212.38, or approximately one-third of the total amount of money available for the installation.

Saanich, B.C.—The total outlay to date on the new waterworks system is $155,000, a great deal of which has been expended for pipe and material which has yet to be installed. Work on the system has progressed far enough to permit the municipality to supply the community.

Toronto, Ont.—It has been announced that the Ontario government will give its approval to the Niagara development idea inaugurated by Sir Adam Beck. The government has also decided to guarantee the bonds of the Hydro-Electric Power Commission. The first flotation will be $500,000.

Vancouver, B.C.—The British Columbia Manufacturers' Association is making plans to build its own ships, of wood or of steel, in British Columbia shipyards, and a joint stock corporation for the purpose of building and operating the ships will be created. It is planned to build from 16 to 20 ships at once in the shipyards of Vancouver, Victoria and Prince Rupert.

Vancouver, B.C.—The Canadian Pacific Railway Co. has announced that only two miles of track remain to be laid to give the company a continuous line from Nelson

to Vancouver over the Kettle Valley lines. The unfinished trackage lies in the Coquihalla section. The official opening of the new line, which is 300 miles long and connects with the C.P.R. main line about two miles west of Hope, will take place in the spring.

Esquimalt, B.C.—Municipal Engineer Gourlay reports that splendid progress was made last year on sewer construction. One section was completed in February and has been in use since that time. That part of the section lying north of the Esquimalt Road was completed in May, but as the sewage in that section has to be pumped to the level of the Esquimalt Road, considerable delay was caused by the necessity of ordering a special pump. A third section, comprising five miles of sewers, was commenced in May and completed in October. The construction of the only remaining section will commence this month.

Windsor, Ont.—The Federal Light and Power Company, of Detroit, has been granted a permit by the United States government to lay cables in the Detroit River for the purpose of transmitting electric power from Niagara Falls to Detroit. The Federal Light and Power Company is an allied company of the Electric Distributing Company of this city, which was organized about six years ago to induce the Ontario commission to extend their transmission line to Windsor, with a view to exporting a large quantity of power to Detroit. Vigorous opposition developed from the start by contesting interests, including the Edison Company, of Detroit.

PERSONAL.

WILLIAM STONE was recently elected water commissioner of Chatham, Ont.

L. A. CAMPBELL has been appointed Minister of Mines for British Columbia.

C. E. TISDALE has been appointed Minister of Public Works of the province of British Columbia.

ARTHUR REID, Commissioner of Public Works for the city of Lethbridge, Alta., has resigned. He is succeeded by Mr. Freeman.

T. SHURMAN ROGERS, of Halifax, has been appointed a director of the Nova Scotia Steel and Coal Co. Mr. Rogers replaces Justice Harris on the board.

Dr. J. T. FINNIE, of Montreal, has been elected president of the Railways and Transport Committee of the Legislative Assembly of Quebec, replacing the Hon. J. C. Kaine.

E. W. BEATTY, K.C., vice-president and general counsel of the Canadian Pacific Railway Co., has been appointed a director of the company to succeed David McNicol, who has resigned.

H. G. GERVIN, chief chemist for the Steel Company of Canada, delivered a very interesting address at the regular meeting of the East Hamilton Businessmen's Club, his subject being "The Manufacture of Iron."

WELDON BEATTY, of Pembroke, Ont., a graduate of the School of Practical Science, Toronto, who has been engaged as a surveyor with the Dominion Government expedition up the Athabasca River, has enlisted for overseas service.

H. N. KEIFER, sales engineer of the Northern Electric Co., Vancouver, who has taken a very active interest in the affairs of the Vancouver section of the American Institute of Electrical Engineers, has been elected secretary of the local section.

KENNETH H. SMITH, B.A., A.M.Can.Soc.C.E., resident engineer at Halifax for the Dominion Water Power Branch, recently visited Ottawa and Toronto to consult with various government officials and consulting engineers. Mr. Smith also has charge of water power investigations in Nova Scotia for the Nova Scotia Water Power Commission.

OBITUARY.

ROBERT ARCHER, a director of the Northern Electric Company, died in Montreal, January 7th. He was 79 years of age.

W. H. MITCHELL, a civil engineer who had been engaged in contracting work for many years, died at Calgary, Alta., recently. Mr. Mitchell was born at Truro, N.S., and lived in Kingston, Ont., until nine years ago. Of late he had been engaged on C.P.R. work.

J. KERR OSBORNE, formerly vice-president of the Massey-Harris Company, Toronto, and for many years prominent in the management of a number of large Ontario manufacturing concerns, died recently at Bournemouth, Hampshire, England. He was 73 years of age and was born in Beamsville, Ont.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—The Thirtieth Annual Meeting to be held in Montreal, January 25, 26 and 27, 1916. Secretary, Prof. C. H. McLeod, 176 Mansfield Street, Montreal.

CANADIAN RAILWAY CLUB.—Fourteenth annual dinner to be held at 8 p.m. January 29th, 1916, in the Green Room of the Windsor Hotel, Montreal. Tickets may be obtained from Jas. Powell, secretary, P.O. Box 7, St. Lambert, P.Q.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—To be held in Chicago, Ill., February 4th, 1916. Joint dinner that evening with American Electric Railway Manufacturers' Association.

NINTH CHICAGO CEMENT SHOW.—At Chicago, Ill., February 12th to 19th. R. F. Hall secretary, 208 South La Salle Street, Chicago, Ill.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Second National conference to be held at Chicago, Ill., February 15th to 18th, 1916. Secretary of the Advisory Committee, J. P. Beck, 208 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION.—Annual Convention to be held in Chicago, February 17 and 18, 1916. Secretary, E. S. Hanson, 538 S. Clark Street, Chicago, Ill.

CANADIAN LUMBERMEN'S ASSOCIATION.—At Ottawa, February 18th, 19th and 20th, 1916, annual convention. Frank Hawkins, secretary, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Meeting to be held in Cleveland, Ohio, February 21st and 22nd. Will P. Blair secretary, Brotherhood of Locomotive Engineers' Building, Cleveland, Ohio.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Thirteenth Annual Convention to be held at Pittsburgh, Pa., February 28th to March 3rd. E. L. Powers secretary, 150 Nassau Street, New York, N.Y.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—At Sohmer Park, Montreal, March 6th to 10th, 1916. Geo. A. McNamee, secretary, New Birks Building, Montreal.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

MAIN GARRISON CREEK STORM OVERFLOW SEWER AND EXTENSIONS, TORONTO

A REVIEW OF THE CONSTRUCTION OF THE NEW GARRISON CREEK SEWER AND EXTENSIONS THERETO, WITH PARTICULAR REFERENCE TO SECTION NO 4, RECENTLY COMPLETED.

By R. T. G. Jack,
Resident Engineer, Sewer Section, Dept. of Works, Toronto.

WHILE the city of Toronto was developing in virtue of its increasing size and population into Greater Toronto, the district bounded by Dupont Street, Lansdowne Avenue, Avenue Road and College Street, an area of approximately eight square miles, was increasing very rapidly in population, new streets were being opened up, permanent roadways placed, manufacturing plants established and many residences built. The district became settled very quickly on account of easy access to and from the more central part of the city. The Works Department, therefore, found that a new and much larger sewer had to be built to relieve the Garrison Creek sewer which had been in commission for over 25 years, and which had become very inadequate to handle the large increase in storm water and sewage. So, when in 1912 a by-law for storm sewers had been sanctioned by the ratepayers, a portion of the money was allotted for the main Garrison Creek and its extensions.

Much time and deliberation was spent on preparing the plans.* Numerous surveys were made to ascertain the best and most economical route, and it was finally decided to parallel the old Garrison Creek sewer as much as possible. For one reason, where the route of the sewer was off the city streets it ran through city property, thereby dispensing with the necessity of acquiring costly easements. Another reason was that over a half a mile of the old sewer runs through ravines and the work could be carried on in open cut, which is less expensive than tunnel work. The third and probably the most important reason was that junctions were to be made at several points for the relief of Garrison Creek sewer, as it was intended to use the latter entirely as a storm sewer.

Work was commenced in the spring of 1912, and the last section of the main Garrison Creek was completed in September, 1915, at a total cost of about $1,200,000, a saving of several hundred thousand dollars over the estimated cost.

The first section to be let was No. 1, which has its outlet for storm water in Lake Ontario at the foot of Strachan Avenue. This outlet is shown in Fig. 7. From this point it proceeds north along Strachan Avenue to Defoe Street, where it turns west and Section No. 2 commences. This was the next section to be tendered for. It runs along Defoe Street to Crawford Street and north to Lobb Street. Section No. 3 starts here and runs west on Lobb Street, north on Shaw Street and crosses Arthur Street to a point 300 ft. north of Arthur Street on Roxton Road, where it intersects the old Garrison Creek sewers, a 5-ft. 6-in. running north, a 4-ft. 6-in. sewer running west. A very large chamber (Fig. 6) was built here for relief of the Garrison Creek south of this point. After this stage had been reached the engineering department decided to construct some of the more urgent extensions, the work on which had already started on Barton Avenue, Section No. 1. By making an outlet for Section No. 1 extension in the old Garrison Creek sewer just south of Bloor Street, it proceeds north through Willowvale Park to Barton Avenue, where it branches, one branch running north to Pendrith Street, west to Shaw Street, north, then west on Manchester Avenue and north on Ossington Avenue. At Ossington Avenue and Hallam Street there is a junction chamber with a section that runs west on Hallam Street. The other branch of the main extension runs east on Barton Avenue to Christie Street, where it branches, one running north on Christie Street to the C.P.R. tracks, the other continuing along Barton Avenue to Brunswick Avenue, south to Lowther Avenue, thence east to Avenue Road.

After these sections had been completed Section No. 4 of the main sewer was commenced, it running north from junction chamber on Roxton Road through Prettie's Ravine to Sully Crescent, east on Sully Crescent to Montrose Avenue, north across College Street and up Beatrice Street to Bickford Ravine, where it intersects the old sewer again. Here another chamber was constructed, and Section No. 5, which was the last section to be let, commences and runs north to the junction chamber just south of Bloor Street.

The chief branch of the main Garrison Creek is Argyle Street storm overflow sewer, a section of which is under construction. This sewer joins the main sewer at Argyle and Shaw Streets, running west to Gladstone Avenue, north on Gladstone Avenue and west to Brock Avenue by way of Trafalgar Avenue, Dufferin Street, Gordon Avenue and Middleton Avenue. It then goes north on Brock Avenue to McConnel Street, west to St. Clarens Avenue, north to College Street and west to St. Helen's Avenue by way of College Street, Lansdowne Avenue and Lum-

*An illustrated article describing the design of the main Garrison Creek storm overflow sewer, sections 1, 2, and 3, showing cross-sections, wier chambers, junction chambers, etc., was published in *The Canadian Engineer* for March 20th, 1913, the author being Mr. R. R. Knight, now City Engineer of Fort William, Ont.

Beverley Avenue. Another branch which the city contemplates building is on College Street running east and west from Montrose Avenue.

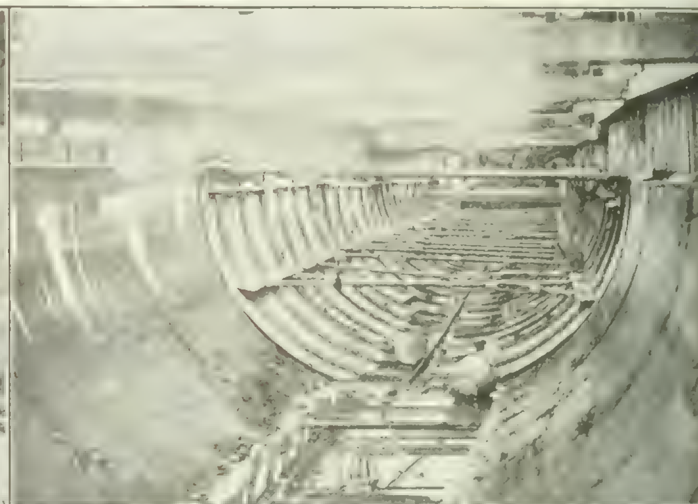
In the main Garrison Creek sewer, sections 1, 2 and 3 were entirely constructed in tunnel, with the exception of a few hundred feet in section No. 1, shafts being sunk at intervals, usually where the manholes are located, and headings driven each way from each. The excavation was brought to the surface by means of buckets or cars that were run on rails in the drifts. After a section of about 8 or 10 ft. had been excavated for walls and arch, forms were placed and concrete run in through a hole that had been previously bored from the street, a workman being stationed to spade the concrete and to see that it was properly placed. The excavation was carried on in the day time and concreting at night. After the allotted time for leaving forms in place (which was 48 hours at least) the forms were removed and 6-in. x 6-in. timbers were placed to protect the concrete from ground pressure until the invert was built. Ground pressure was very considerable in these sections as the material through which these sewers run is, in most places, a soft blue clay.

When the concreting of walls and arch had been completed between two shafts, the invert was concreted and brickwork laid, the 6-in. x 6-in. braces being removed as the work progressed.

It might be stated that the contractor on section No. 1 did not think it necessary at first to take any precaution against the ground pressure after he removed the forms, so he had a section to reconstruct as the walls "kicked in" to a considerable extent.

The design of sewer for these three sections (1, 2 and 3) was a culvert shape, with 18-in. class B concrete (1 : 3 : 5) in walls and arch, the invert being 14 in. of class B concrete and finished with paving brick to stand the wear of the water.

In section No. 1 there are four sizes, 10 ft. 8 in. x 10 ft. 8 in., 8 ft. 5 in. x 10 ft. 8 in. (reinforced under G.T.R. and C.P.R. tracks), 10 ft. 3 in. x 10 ft. 3 in., and 9 ft. 6 in. x 9 ft. 6 in. In section No. 2 there are two sizes, 9 ft. 3 in. x 9 ft. 3 in. and 8 ft. x 10 ft. The latter has a small oval sewer 1 ft. 9 in. x 3 ft. 0 in., alongside it to take care of the dry-weather flow from the Argyle Street section of the storm overflow sewer and convert it into the Queen Street sewer and thence into high level interceptor, through which it finds its way to disposal plant. Section No. 3 is constructed in two sizes, 10 ft. x 10 ft. and 9 ft. 6 in. x 8 ft. 4 in.



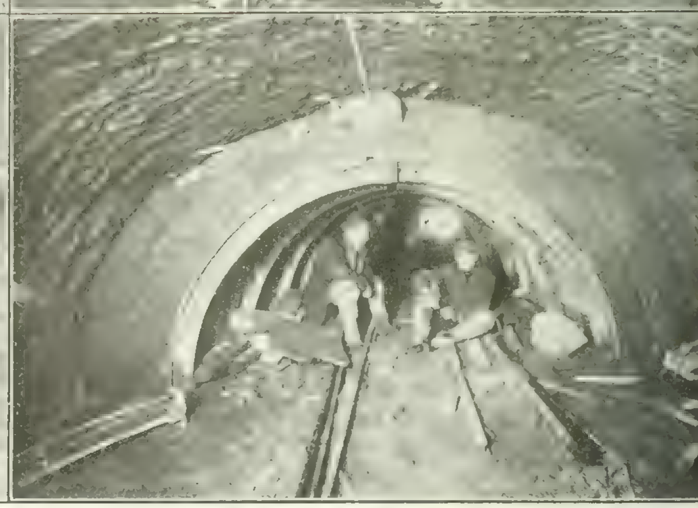


Fig. 1.—Open-cut Portion of Section No. 4, Showing Method of Mixing and Transporting Concrete.

Fig. 2.—Main Garrison Creek Storm Overflow Sewer, Showing the Use of Steel Forms for the Invert.

Fig. 3.—Placing One Ring of Red Shale Brick in Invert After the Arch Had Been Completed. Section No. 4.

Fig. 4.—Showing Method of Excavating in Tunnel, also Steel Circular Ribs and Lagging in Place. Section No. 4.

Section No. 4, which is dealt with in detail in a later portion of this article, was constructed partly in open cut and partly in tunnel, as part of it was in very shallow ground. There are three sizes, 8 ft. 0 in., 9 ft. 6 in. and 9 ft. 3 in. circular with 18 in. of class B concrete and with brick invert.

As section No. 5 was in Bickford Ravine the plans called for open-cut work, but a short section ran through a knoll of very hard clay. This portion was tunnelled, 18-in. brickwork being used in construction.

Owing to the unsatisfactory condition of the old Garrison Creek sewer through Bickford Ravine, it having cracked open on several occasions when under a heavy internal pressure, it was decided to abandon its use altogether and to use section No. 5 for a combined sewer. A junction chamber was placed at the entrance to section No. 4 with a weir which diverts the sanitary flow into the old Garrison Creek sewer and allows the storm water to go on down section No. 4.

In the Argyle Street storm overflow sewer, section No. 1 was 6 ft. 0 in. circular and of 18-in. brickwork. It was intended by the engineering department to construct this of concrete, but after a shaft had been sunk and tunnel work started, it was found on removing the braces from the concrete forms that the 18-in. concrete wall would not withstand the pressure of the soft blue clay through which the sewer was to run. The design was, therefore, changed from concrete to brickwork, which was placed satisfactorily.

Section No. 2 is constructed in two sizes, 5 ft. 6 in. and 5 ft. 3 in., with 14 in. of brickwork. In this section a much harder blue clay was encountered and the work was completed very rapidly.

Section No. 3, which is now under construction, is of uniform size of 4 ft., some sections having 9 in. of brickwork and others 14 in., the latter thickness being used where there is a heavy ground pressure.

All the extensions decrease in their sizes as they recede from the outlet.

The following table relates to the size and shape of each of the various sections, together with material of construction and nature of excavation work:—

[illegible]	Size	[illegible]	Material.	Excavation
Barton Ave., Sec. No. 1	[illegible]	[illegible]	[illegible]	[illegible] Open Cut
	[illegible]		"	Tunnel
	[illegible]		"	"
Barton Ave., Sec. No. [illegible]	[illegible]	"	"	"
	[illegible] x 4' 9"	"	"	"
	[illegible] x 4' 6"	[illegible]	Brick	"
	2' 4" x 3' 6"	" "	"	Open Cut
	[illegible] 3"	"	"	" "
Extension No. 1	[illegible] x 7' 6"	[illegible]	[illegible]	Tunnel
	[illegible] 6"	"	"	"
	[illegible] x 6' 6"	"	"	Open Cut
	[illegible] x 6' 0"	"	"	Tunnel
	[illegible] x 5' 7"	"	"	"
Extension No. [illegible]	[illegible] x 5' 7"	"	"	"
	4' 9" x 5' ½"	"	"	"
	6' 0"	Circular	Brick	"
	[illegible]	"	"	"
Christie St.	4' 0"	"	"	"

Main Garrison Creek Storm Overflow Sewer, Section No. 4.

	Lin. ft.
Length of sewer constructed	3,425
Length of sewer in open cut	[illegible]
Length of sewer in tunnel	[illegible]

	Lin. ft.
Length of 8'–0" circular sewer	1,341
Length of 9'–6" circular sewer	774
Length of [illegible] circular sewer	[illegible]

Material used in construction—

Arch—Concrete, in proportion of 1 part cement, [illegible] sand and 5 of broken-stone or gravel; 18" in thickness.

Invert—Concrete, same proportions, [illegible] in thickness, and one ring [illegible] of hard red shale bricks.

Location.—Starting at the junction chamber of the old Garrison Creek sewers and section No. 3, main Garrison Creek storm overflow sewers on Roxton Road, 150 ft. south of Harrison Street, it runs north on a 500-ft. curve for 400 ft., then straight northeast to Sully Crescent, through Prettie's Ravine. Passing under Shaw Street bridge, it goes east on Sully Crescent to Montrose Avenue, north to College Street, turning east on College Street to Beatrice Street and north on Beatrice Street to Bickford Ravine, where it joins section No. 5 of main Garrison Creek sewer.

Design.—Owing to the decided difference between the elevation at the outlet and the elevation that was to be used at Sully Crescent, it was possible to design an 8-ft. circular sewer with a fall of 1 ft. in 108 ft., that was large enough to take care of the volume of water that the following sewers, 9 ft. 6 in. and 9 ft. 3 in. with a fall of 1 ft. in 300 ft., were capable of carrying. If a sewer of uniform size and with a constant grade had been chosen from the inlet to the outlet its depth at College Street would have been much greater than the one constructed, thereby increasing the cost of construction, as the sewer was constructed just at the bottom of a clay strata with wet sand

Fig. 5.—Meeting of Two Headings, Main Garrison Creek Storm Overflow Sewer, Section No. 1.

below. Had it been lower, the sand would have given far more trouble.

Borings, which had been taken to ascertain the nature of the materials through which the sewer was to pass, showed a layer of wet sand just above subgrade in some places and at spring line in others. It was therefore decided that owing to the presence of the sand every precaution possible was to be taken against settlement, and the sewer in the open cut was designed with a square concrete base. In the tunnel section 1,090 lin. ft. were constructed with a circular base owing to the absence of the sand, but in the last 700 lin. ft. the layer of wet sand came into prominence again, and on account of the method of construction which will be described later, this portion was constructed with square base. The sides were excavated straight and planks placed to keep sand from running in and thereby forming a cavity back of the arch which would allow it to spread, and also to keep sand from mixing with the invert concrete as it was being poured.

Under the Shaw Street bridge a short section (72 lin. ft.) of sewer was constructed with a square concrete top, the invert, walls and arch being reinforced with .50 mesh, 1.83 lbs. per sq. ft. This design was used here because a number of the bents of the bridge were being carried by the walls of the sewer.

Open Cut Section.—Work was started on the open cut section by sinking a shaft at Sta. 16 + 35, which was at the end of the open cut and the commencing point of tunnel work. Contrary to expectations, the ground turned out to be a very hard clay in this portion of open cut, right down to sub-grade. This shaft was used afterwards for a working head in tunnel work. The excavation in the open cut proceeded from this point to Sta. 0 + 00, a stop being made for two months at Sta. 12 + 35 when the cold weather set in. The excavation was done by an Ohn bucket on a travelling derrick, which proved to be much more economical than hand work, the excavation being removed for 62 cents a cu. yd. throughout the open cut.

Before closing down for cold weather 400 ft. of sewer was constructed, wooden forms being used for the concrete work. The concrete in the invert and arch was first run, after which the brick invert was laid.

When the worst of the cold weather was over, operations were resumed on this portion of the work (the tunnel work having gone on without interruption).

work to be placed in the invert. After the invert forms were set the concrete was placed and after this had set sufficiently the turnbuckles were released and the 60 ft. of forms were drawn ahead by the engine of the excavating machine. The brick invert was next laid. Then, 6-in. x 6-in. timbers were placed on the brickwork just high enough to allow a 2-in. plank to be placed, to run the arch forms on when released, the arch forms being blocked to proper elevation off the 6-in. x 6-in. timbers. When the concrete had been poured and had set 48 hours the forms were released and drawn ahead as in the invert. These steel forms were certainly a big improvement on wooden forms as they could be set up in much less time and gave a much more superior finish, requiring very little, if any, pointing up.

The concrete in the first section of sewer completed was all mixed at Sta. 16 + 35, where a steam plant was installed to heat the material and run the mixer. The aggregate was placed on a knoll just above the mixer and the concrete dumped into cars below, which conveyed it

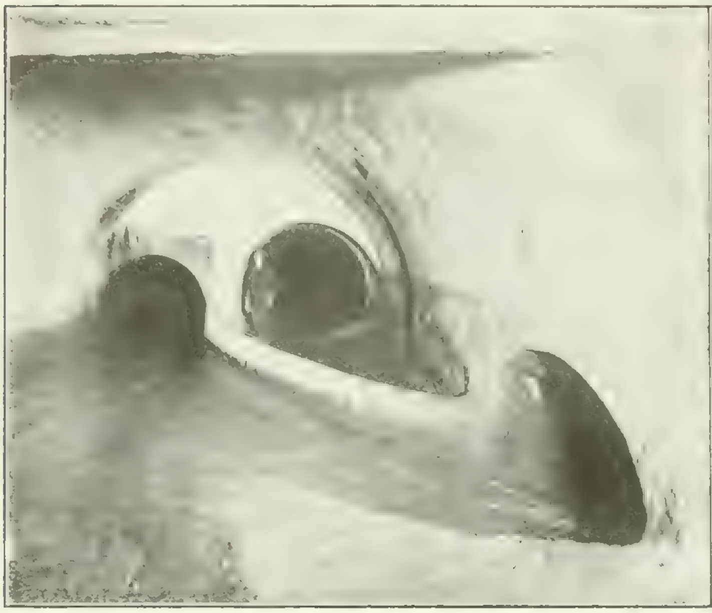


Fig. 6.—Junction Chamber, Viewed from Bellmouth of Section 4, Showing Section 3, Old 6 ft. 6 in. and Old 4 ft. 6 in. Garrison Creek Sewers on the Left and Right Respectively.

Fig. 7.—Outlet of Main Garrison Creek Storm Overflow Sewer at the Foot of Strachan Avenue.

In the balance of the open cut, 700 lin. ft. of it was in the ravine where the excavation was very shallow and the work went on very rapidly. Steel forms were used in place of the wooden ones and by so doing 240 ft. of invert and 180 ft. of arch could be finished in six days. These steel forms were manufactured by the Blaw Steel Form Co. They were made in 5-ft. sections and 12 complete sections (60 lin. ft.) were used. Each section was made in four pieces, two for arch and two for invert, the arch pieces being bolted together at the centre and separated by tie rods, which were operated with a turnbuckle, at spring line and half-way between spring line and centre of arch. The different sections were held together by U-s in one section passing through holes of the next and held flush with small oak wedges. Each section had four castors riveted to the angle plates at the spring line, to be used in pulling the forms ahead without being taken apart. The invert forms are practically the same, only they did not have the castors, and were 9 in. wider in diameter to allow for the one ring of brick-

along the line of work on tracks situated at the side of the trench. In the last section, two similar points were picked out for the mixer, but electricity was used for the motive power, proving much cheaper than either gasoline or coal.

The surplus excavation in the section from Sta. 16 + 35 to 12 + 35 was hauled to a nearby dump so the backfilling material for this section was obtained from the tunnel. This was brought to the surface on the elevator at the shaft, dumped into the concrete cars, and carried along to where it was needed. In the section between Sta. 12 + 35 and Sta. 5 + 00 there was no backfilling done as the arch of the sewer was above the ground elevation (Fig. 1) and as the city is filling in this ravine with ashes. But between Sta. 5 + 00 and 0 + 00 the excavation was piled up alongside the trench and after the sewer was completed it was replaced in the trench by the excavating machine.

Tunnel Section.—This is the portion of the contract where the contractors anticipated trouble owing to the

borings showing a layer of wet sand. Most of the contractors who placed a tender for this work calculated on having to install a compressed air plant to facilitate in the excavation work. This was the reason for vast differences in prices submitted, the successful bidder being nearly $20,000 less than the second one.

The work in the tunnel was carried on from four shafts, which were situated at locations for manholes. Steam hoists were used to operate elevators, which brought the excavation from the tunnel to the surface in cars, where it was dumped into wagons, taken to Bickford Ravine and used for filling-in purposes.

The method of excavating was rather unique, having never been tried in Canada before. Contrary to the usual custom, which is to excavate the full size of bore at once, only the upper half was removed, the lower half or bench being left in place until all the excavating and concreting of the arch had been completed in that heading. Tracks

Fig. 8.—Junction Chamber at Lappin Avenue, Section 2.

were laid on this bench and the excavated material carried to the shaft in cars. This bench was also useful as a foundation for the concrete forms (Fig. 4). Lengths of 12 to 15 ft. were excavated at a time, and after each had been concreted another length was taken out, and so on until the entire drift was finished in the arch. Then the excavating of the invert commenced, this being taken out in alternate lengths of 12 to 15 ft. Trestlework was placed under the tracks as the excavation was removed. Forms were then set and filled to within 1 ft. of the arch concrete, this space being underpinned with brickwork after the concrete had set for at least 48 hours to allow for any shrinkage. When these alternate lengths were finished throughout the drift the intervening portions were treated in the same way. By this method of placing the invert the arch was never without support for any greater length than 15 ft., for when the alternate sections were being taken out the intervening sections carried the arch, and when the intervening sections were removed the invert had the load.

In concreting the arch, steel circular ribs of 4-in. channel iron, with 2-in. wooden lagging, dressed on three sides, were used for the form work. These steel ribs did not require any bracing (Fig. 4) and thereby allowed the cars to be taken right up to the face of the work. In the invert, wooden ribs with 1-in. sheeting were used for form work, allowance being made in placing them for the one ring of brick that was to be laid. When all the concreting

Fig. 9.—Showing Method of Excavating and Nature of Material, Section 2.

had been completed the trestlework and tracks were removed, all the surplus concrete was trimmed off and the brick invert laid. The concrete in the arch was mixed rather wet until the centre of the arch was nearly reached, when it was stiffened up and rammed back on the forms with hoes. In the invert the concrete was made as wet as possible to assure that no voids would be left, as it was being poured in a rather awkward place and tamping was almost impossible.

Fig. 10.—Tunnel Part of Section 4, Showing Method of Excavating and Underpinning.

As in the open cut, electric motors were used to drive the mixers, which were situated in a hole excavated alongside the shaft, large enough for mixer and motor. The concrete was deposited through a chute in the shaft to cars below, which conveyed it to the forms.

This method of construction proved very satisfactory, for, had the whole bore of sewer, which was 12 ft. 6 in. in size, been removed at once, sheeting in all probability would have been required to protect the arch excavation, owing to the wet sand in the invert; whereas, the excavation in the entire length of tunnel, with the exception of 50 ft. where a dry sand pocket in the arch was encountered, was carried on without the aid of timbering, which is a very heavy item of expense in tunnel construction, especially of this size. By not removing this bench it provided a working place both for mining and placing concrete in the arch. Such a bench would have had to be constructed had the whole size of sewer been removed.

Another innovation contrary to usual method of sewer construction was that the excavation was carried on at night and concrete and brickwork were placed in the day time. This proved much more satisfactory for the engineer and inspector, as it was possible to see that the materials were properly prepared before going into place.

The following figures are from cost data kept by the writer, who was resident engineer on this section.

Labor.

	Cu. yds.	Cost per cu. yd.	Remarks.
Excavation ..	11,332	$ 0.62	Done with clam, including placing sheeting, pumping, etc.
Backfilling .	[illegible]	.15	Done with clam, including pulling sheeting.
Surplus ...	.....	Nil	Just placed along line of sewer.
Forms ...	. .	.....	Wooden forms, 3c. to place and 6c. for material. Steel forms, $900 rental for 60 lin. ft. of 8 in. dia.
Concrete—			
Open cut...	[illegible]	1.10	Including placing forms, heating material and finishing, not including cost of material, as same forms are used over again.
Tunnel—			
Arch .. .	[illegible]	1.75	Including placing forms, heating material and finishing, not including cost of material, as same forms are used over again.
Invert .. .	1,762	2.25	Including placing forms, heating material and finishing, not including cost of material, as same forms are used over again, and form-work in four manholes.
Brickwork—			
Invert ...	691	6.15	Including trimming off concrete, etc.
Underpinning	[illegible]	2.00	Average of 3 cu. ft. per lin. ft. of 1,790 ft. sewer.
Tunnelling—			
Arch .	[illegible]	1.60	Including sinking three shafts, hauling to and handling at dump.
Invert	1,610	1.40	Including sinking three shafts, hauling to and handling at dump.

Material.

Concrete—			
Stone	6,500	$ 1.50 cu. yd.	Stone and gravel used.
Sand .	[illegible]	1.00 cu. yd.	
Cement	33,200	0.40 bag.	
Brick Invert—			
Brick . .	305,400	9.00 per M.	
Sand .	380	1.00 cu. yd.	
Cement	3,845	0.40 bag.	
Underpinning-			
Brick ...	61,400	9.00 per M.	
Sand . .	[illegible]	1.00 cu. yd.	
Cement	[illegible]	0.40 bag.	
Lumber .	41,600	22.00 per M.	Left in trench and tunnel.
" .	23,000	15.00 per M.	
Reinforcing .	[illegible]	0.04 lb.	Used in Sec. B and in manholes and junction chamber.

These figures do not include any overhead expenses or any allowance for depreciation of plant.

Work commenced November 20th, 1914, and was completed September 30th, 1915.

	Lin. ft.
Length of sewer in contract	3,405
*Length of sewer constructed	3,425
Length of sewer in open cut	1,635
Length of sewer in tunnel	1,790

* Twenty lin. ft. of extra sewer.

	Lin. ft.
Length of 8′ 0″ square base and circular top	1,269
8′ 0″ square base and top	72
9′ 6″ square base and circular top	295
9′ 6″ circular base and top	479
9′ 3″ circular base and top	610
9′ 3″ square base and circular top	700

Material used in construction—
Arch —18 in. class "B" concrete.
Invert—14 in. class "B" concrete and one ring of hard shale brick.

This work was carried out under the direction of Mr. R. C. Harris, Commissioner of Works, and Mr. Geo. G. Powell, deputy city engineer. Mr. W. R. Worthington is assistant engineer in charge of the sewer section, Department of Works, and Mr. W. G. Cameron was division engineer supervising the work.

POWER ENTERPRISES AT EDMONTON.

During the year it is the intention of the Edmonton Power Co., a corporation with headquarters at Montreal, to construct a dam across the Saskatchewan River at Rocky Rapids, about 75 miles west of Edmonton. The dam will be about 1,000 ft. with a head of 80 ft. Power will be transmitted to Edmonton and the city has entered into a contract with the power company to pay for the power delivered at the city limits. A railway will be built from the city to the dam, this wall will be about 80 miles, equipped for electric power. The firm of Fairchild, Jones and Taylor, consulting engineers, Edmonton, will do the engineering on the railway, according to a recent announcement. Total cost of undertaking including dam, railway and transmission line will be about $6,000,000. Edmonton has given a franchise to the Northern Alberta Gas Co. to sell natural gas in the city at 25 cents per 1,000 and this company will build a pipe line and distribution system. The line will be about 90 miles long and will supply small towns between the gas field and the city. The gas field is on the Battle River Anticline southeast of the city. The same firm will do the engineering. The cost of the work is estimated at about $4,000,000.

SOIL-TESTING AND EXCAVATION FOR FOUNDATIONS.

SOME general notes on foundation work were presented to our readers in *The Canadian Engineer* for December 9, 1915 (p. 671) in which a brief reference was made to the method by which soils are tested as to their suitability for foundations. The method, that of making wash borings, receives more detailed consideration in the following abstracts from Mr. Chas. T. Main's paper as read before the December meeting of the American Society of Mechanical Engineers. The writer takes up also the subjects of excavation, cofferdamming, piling and other phases of general foundation work, and his comments concerning them are also summarized.

Wash Borings.—These are made with the aid of a tripod, iron or steel casing, drill-rod, hose, force-pump, bucket, etc. The tripod used to support the casing and drill-rod usually stands 12 to 15 ft. high. The casing is usually made of heavy pipe, 2 to 2½ in. internal diameter, and inside it works a heavy, hollow drill tube or rod, 1½ to 1¾ in. outside diameter. This drill-rod is fitted at the bottom with a chopping bit having openings in it for the water jet, while the top is connected with a water hose and force-pump, the latter usually double-acting. In action, the water is forced down through the drill-rod, jetting through the holes at the chopping bit and carrying up the loosened material in the annular space between the rod and case.

The method of forcing the casing and rod down depends on the character and density of the material encountered. In soft material very little effort is required to work the rod down, while in hard material more or less lifting and dropping or churning will be required.

In order to record changes of strata and take samples of the soil, it is necessary to know the level of the bottom of the drill at all times and to watch the overflow for the color and character of the soil. In taking samples the overflow is caught in a bucket and allowed to settle. The samples are taken and placed in glass bottles carefully marked with the boring number, sample number, character and thickness of the stratum which the sample represents. To be complete the records should also include the level of the ground water and the elevation of the surface of the ground at the boring referenced to some datum.

Wash boring samples do not always represent closely the true character of the soil, as the water jet and chopping bit change it radically by breaking it up and separating the fine from the coarse material; the coarse parts are mostly pushed aside while the fine parts are taken to the surface by the water flow. The presence of clay in sand may be easily overlooked, while a hard clay suitable for supporting a structure may be reported as a soft one and unsuitable.

More reliable samples may be obtained by withdrawing the drill-rod and forcing a pipe into the soft soil, then bringing the pipe to the surface, thus obtaining a dry sample in nearly its natural state. In hard soils, such as very hard clay, soft slate or shale, the pipe for taking samples may have its lower edge sawtoothed, and the most satisfactory samples may be obtained by working this without the water jet.

Test-Pits and Rods.—Test-pits furnish the opportunity of observing the character of soil, its degree of compactness, amount of moisture, etc., but to be of full value they should be carried well below the level of the bottom of the foundations. In cases where the strata change with the depth, a test-pit gives no sure indication of the soil below the foundations unless carried deeper than the level of the footings.

Testing soil with a rod is an unsatisfactory method and cannot be relied upon to give accurate information except in a limited number of cases. In a homogeneous material, not too hard, the method is valuable in determining the constancy or varying density and resistance. In a heterogeneous soil, the sinking of a rod may be stopped by a layer of hard gravel, a rock or log, and would not furnish reliable or complete information.

Excavation.—Work on foundations consists of excavation of earth or rock, including shoring, sheet piling, or cofferdams, and a structure of stone, concrete, brick or timber at the bottom of the excavation, including bearing piles. In nearly all cases the expense of excavation will increase with the hardness of soil and inconvenience for working; but if the excavation is in sand or soft earth, with considerable water to contend with, the cost is largely increased by the necessary structures for enclosing the excavations and sustaining the banks.

Earth is hard in proportion to the amount of cementing material which it contains, and its temporary stability also depends on the amount of this material, while its permanent stability depends upon the friction of the particles on each other. The disadvantage of hardness for excavation is offset in many cases by the advantage of the self-sustaining power of the vertical cut for a time sufficient for the work on the foundation to be completed. If a vertical cut is exposed for a long time to the weather, it may become dangerous. The effect of an excess of moisture, freezing and thawing, or drying out is to crack off the bank and gradually to approach the natural slope of permanent stability. If the time required to lay the foundation be very long, or the weather unfavorable, it may become necessary to shore up, even in firm earths, but in a much less expensive manner than in material which has a tendency to flow.

Usually, in working in clean sand or gravel below a depth of 5 to 6 ft., shoring may be done by laying in planks horizontally along the sides of the banks, putting in vertical timbers or planks at short intervals and opposite each other, and bracing between them. Even with this sort of shoring, it is well to make it secure, so that no braces or other pieces may drop out and injure any person, or perhaps cause a slide.

When sand containing water, or soft clay with running water is encountered, the saving of soft excavation is entirely absorbed by the expense incurred in sustaining the banks and preventing damage to any adjacent buildings. Sheet piling must be used here, which consists of planks or timbers driven closely together and of a thickness varying from 2-in. plank to large timbers, according to the depth, pressure, and soil. Four-in. plank is about the thickest used in ordinary work. Three to 6-in. plank should be grooved on edges, the grooves to be filled with splines.

The usual way for driving sheet piling is to lay out the line for the sheet and on it drive some guide piles, the excavation being carried down as far as possible before commencing to drive. To the guide piles, inside and outside, are bolted or spiked stringers or rangers, which serve as guides for the piles at the top; a second ranger on the inside serves as a guide while the soil presses the pile from the outside. The bottoms of the piles are tapered off, and also cut slanting, so that there

will be a tendency to crowd against the next one already driven. To prevent splitting while driving, the tops should be protected with an iron ring; the piles are driven far enough below the grade of the bottom of foundation so that no outward pressure can break them below the bottom ranger. As the excavation is carried down, these rangers are put in at a distance of 5 or 6 ft. apart and the bracing from side to side done on them. Although this is only a temporary structure, all the piles should be new and sound, as they are subjected to severe strain while being driven. New piles can be used again elsewhere if extracted, while shaky timber would cause trouble and perhaps cripple the sheeting, besides being useless after extraction.

Where any large amount of sheet piling is done, the steam hammer is the best driver to use, or if this type is not available, the ordinary pile-driver with falling weight can be used to advantage. The hammer should be lighter than that for driving bearing piles. Where the work is not very large, the piles may be driven with heavy beetles or mauls, but this method is extremely slow for thick sheeting. When driving by steam, a good many light blows of the hammer is better than a few heavy ones and the practice is not so apt to cripple the planks.

In commencing construction of a building it is customary to cut the trench around for the outside walls, leaving the earth which comes inside the building for the support of the sheeting until the walls are built and set enough to receive the outside pressure.

Cofferdams.—These are built for the exclusion of water while work is being done. The kind employed depends upon the nature and extent of the work, and the strength should be somewhat in proportion to the amount of damage or delay from failure. As the space and amount of puddling material are usually limited, the best and usual form will be a bank of puddle enclosed and supported by a row of sheet piling on each side. Experience has shown that 4 to 6 ft. is sufficient for the puddle to exclude the water; but unless the dam is supported independently, its width must be in proportion to the depth of water, so that it will not be overturned. Good timber should be used here as in ordinary sheet piling and for the same reasons. Where there is room, a bank of sand against the inside sheeting will assist in supporting the dam.

Single-sheeted dams are sometimes used successfully. They are made from planks, tongued and grooved, or carefully caulked, but they can only be used successfully where the soil is not of a flowing nature; otherwise, when the pressure is relieved from the inside, the flow will start under the bottoms of the sheeting and render the dam useless. This sort of dam should never be trusted where its failure would cause much damage or expensive delay. A double dam will, in nearly all cases, pay for itself.

Bag Dams.—Where the depth of water is not great, bag dams can be used to advantage. They can be cheaply and quickly constructed, and in some cases are almost indispensable. They can be used for shear dams for turning water away from foundations, especially where sheet piling cannot be driven, for repairing breaks in banks and for many other purposes. They are made from strong empty cement bags or gunny sacks filled with sand or other suitable material and securely tied and deposited in the place where they are to be used.

Disposal of materials of excavation should be made in the cheapest and quickest manner. If by carts, and the inclination is not too great, a run should be made from the surface to the bottom of the excavation, and the carts backed down and filled. If by wheelbarrows, the run should be the same. If loaded into cars on a side track, the material may, on any sizable job, be hoisted by derricks operated by steam power, in scales, and dumped into the cars. If it is impossible to load carts in the excavation itself, they may be loaded in the same manner as the cars. In excavating the trenches in soft material the hoisting method must be used. Where the amount of excavation is large, steam shovels can be used to advantage.

Material to be used again for backfilling should be put in a convenient place, and backfilling should be begun as soon as possible, to protect the foundation from the weather and for convenience in working.

Piling.—Where the depth of good bottom is too great to be reached economically by the foundations, approximately 10 ft. or more, it becomes necessary to use piles. The determination of the type of piles depends upon local conditions. If it is necessary to spread the load over as much area of the underlying land stratum as possible, wood piles should probably be used. If it is not necessary to spread the load, a fewer number of concrete piles with higher bearing value can be used. If the ground water is comparatively low down, it may be much more economical to use concrete piles and carry the foundations down to the ground water level than to use wood piles.

The kind of wood to use for piles is governed by the kinds which are obtainable at the location under consideration and the character of the soil through which it is to be driven. Soft wood, like spruce and white pine, can be driven into soft soils safely, but in hard soils there is danger of brooming the points or crippling the pile, and oak, southern pine or some hard wood should be used. As stated above, an exploration of the site should be made by borings in order to design properly the pile work.

The driving is done by either a drop hammer or a steam hammer. In sandy soils and soils containing gravel the driving can be assisted by the use of a water jet. The final blows to test the rate of penetration should be made after the water is shut off. Indication of overdriving is shown by the bouncing of the hammer and by bending and kicking. The length and size of the piles and character of the soil determine the weight and drop of the hammer.

John Millen & Son, Limited, of Montreal, have sold stock, assets and goodwill of their railway and supply department as a going concern to Frank D. Lyman, who has been manager of the department for the past nine years. Mr. Lyman will carry on the business under the firm name of Lyman & Lyman, Limited, with offices at Montreal and Toronto.

The Dominion Chain Company, with Dominion charter, has increased its capital stock from $50,000 to $500,000; the North American Chemical Company, Limited, with Dominion charter, from $30,000 to $100,000; Ford Motor Company, Limited, with Dominion charter, from $1,000,000 to $10,000,000; Soulanges Rural Telephone Company, with Quebec charter, from $5,000 to $10,000.

British Columbia has produced $73,269,603 of placer gold, $81,595,516 of lode gold, $37,709,282 of silver, $31,468,462 of lead, $86,939,370 of copper, and $149,814,462 of coal and coke; $26,026,050 other metals and building-stone, etc., a total production of $486,822,745. The mineral production for 1914 was $26,388,825. Lode mining has only been in progress for about 22 years, and not 30 per cent. of the mineral land has been even prospected; 250,000 square miles of unexplored, mineral-bearing land are open for prospecting.

FACTORS AFFECTING THE LIFE OF CONCRETE STRUCTURES.

No structure is permanent, in the strict sense of the term, no matter what the constituent material or materials may be. The degree of durability is accordingly an item of great importance in the consideration of all materials of construction. In the majority of cases the most used have achieved their rank by virtue of their resistent qualities, and their general use has resulted from carefully gleaned knowledge and proven skill on the part of engineers of experience.

In this respect the acceptance of concrete, since the time when Portland cement came to be regarded as one of the principal construction materials, was viewed with distrust by many a doubting Thomas. It cannot be denied that the doubts concerning its permanence and reliability were justified, so many early failures occurred, due to crude preparation of cement, rule-of-thumb methods, and inadequate knowledge of the cementing qualities of the constituents of the resulting mixture. Each failure added weight to criticism and incentive to critics.

But concrete has survived; there are surely few engineers who do not rank it among the most resistent structural materials known. It is needless here to review the preponderous investigation and study through which only it gained its worthy classification.

The probable life of concrete structures is a subject having to do with the possible causes of their destruction, and a consideration of the latter serves well as a basis for an estimation of the former. Mr. Bertram Blount, of London, Eng., addressed the International Engineering Congress, in September last, upon the probable and presumptive life of concrete structures made from modern cements, outlining in the case of both plain and reinforced concrete the chief causes which determine their life. In the majority of cases what affects plain concrete affects reinforced concrete and vice versâ; but the probable life of reinforced concrete involves a consideration of the steel severally and jointly, in addition to that of the concrete.

The possible causes of destruction of ordinary concrete as distinguished from reinforced concrete are listed by Mr. Blount as follows: Bad cement, bad aggregate, bad proportions, bad mixing, bad workmanship, bad design, external violence, fair wear and tear, action of saline solutions, action of acids, electrolysis; and all the foregoing causes of destruction are operative towards reinforced concrete as well as plain concrete. In addition there are: (1) corrosion of reinforcement direct or by electrolysis. (2) cracking due to monolithic character or possibly to stresses between the concrete and the reinforcement.

With these causes Mr. Blount's paper deals in part as follows:—

The best modern cement made of suitable raw materials, intimately mixed, thoroughly burnt and finely ground, is as dependable a material as can be prepared until the time comes when all cement is made by fusing the constituents in a sort of super-blast-furnace, a method tried some years ago, and one which is regarded by many as an advance on the present rotatory process. But these conditions of excellence are not always fulfilled. Chiefly because of the endeavor to obtain large outputs of cement per unit of plant the control of proportions is sometimes inaccurate, the burning not uniform and the grinding not only coarser than is desirable but "gritty." Such cement fails in respect of the first quality absolutely essential to the stability of any structure of which it forms part—it is not sound. Quite useless is it to say that such unsound cement has been used and the structures made with it are standing; the point of interest is how many have fallen down. Further, there is the pregnant question whether a buyer will not insist on a material which is certain to be free from vice, or whether for the convenience of the seller he will trust to luck. Generally, the man who pays can and will get what he wants. It may be confidently said that, given careful manufacture, rigid inspection and thorough testing to a searching specification, modern cement can be obtained free from all inherent vice, and that structures of which it forms part will not be brought to a premature end by internal treachery.

Bad aggregate is a fruitful source of trouble, and, simple as it is in a specification to say that the aggregate shall be "suitable, clean, sharp, well washed," and so on, it is not always easy to get such an aggregate at a reasonable price. Local material must almost always be used, and it may be of the most diverse description. The one property, which is indispensable, is that it must be chemically stable under the conditions in which it is to be used. It does not follow absolutely that the aggregate shall be stable *per se*, though it is much better that it should be; there are materials which oxidize, or which weather, that may on occasion act as a serviceable aggregate, but only urgent necessity will sanction their use. Thus, in general, rocks containing pyrites should be avoided, but it would be pedantic to reject a granite or a hard limestone on the sole ground that specks of pyrites are present. Not merely the amount and size of the enclosed pyrites should be considered; naturally a rock containing marcasite is *ipso facto* suspect. In such cases, petrological methods of examination should be used. Similarly, slags, such as copper slag containing much ferrous silicate, may well be used if their silica content is high enough; generally, such slags lie in dumps, and have so lain for years, and their behavior during exposure to weather is a great guide. The same remark applies to blast furnace slag. Analysis is very helpful if the results are carefully interpreted, but the behavior of the material on the dump is even better. Speaking generally, substances containing sulphates or sulphides, capable of oxidation under working conditions, are so dangerous that their use should not be tolerated, and the need of this restriction can be the better realized when it is remembered that 1% of SO_3, calculated on the aggregate, may mean 5% or more on the cement. Perhaps, of all the materials used as aggregate, the most dangerous is coke breeze. The danger lies in the fact that some samples contain an abundance of sulphates, and, on account of the porous nature of the breeze, these are readily extracted, and do their deadly work on the cement. No sample of breeze should be used as an aggregate unless it has been analyzed and tested. Aggregate may be mechanically as well as chemically bad, but exactly how to define that badness is not easy. Such obvious defects as softness, cracks or excessive smoothness need no more than mention, but how far a "dirty" aggregate carries its own condemnation, is a more difficult matter to decide. It may safely be said that clayey matter round the coarser lumps will prevent a proper bond, but the effect of a moderate amount of clayey matter in the sand is not necessarily harmful. Like most practical things, it is eminently a matter to be settled by trial, and test cubes of the proposed aggregate compared with similar cubes of some aggregate recognized as a standard, such as granite chips and clean sand, will decide the point. Four other causes of short life for a concrete structure, *viz.*, bad proportions, bad mixing, bad workmanship and bad design, call for little comment except this, that evil as are all these for ordinary concrete, they are ten times worse for reinforced concrete, because, while ordinary concrete is generally used in considerable masses, a structure of reinforced concrete is a more delicate affair in which all

four sources of mischief have a greater say. Particularly is this the case in respect of bad proportions and bad workmanship. All reinforced concrete should be as nearly impervious as can be contrived, as it is of the utmost importance to protect the reinforcement; and although it is true that iron is protected in an alkaline medium, yet reliance should not be placed on that alone; it is far sounder practice to make concrete of all kinds, and especially reinforced concrete, as nearly watertight as is practically possible.

The life of concrete structures may be shortened by causes which are external to itself. The violence of wind, wave and earthquake, the effect of the subsidence of the soil, etc., will destroy any structure however well made. But, in practical affairs, one does not legislate for the infinite, and is content to make structures so good that ordinary natural violence will have little effect. The simplest and most important case is that of making harbors which must resist all these natural forces. Thanks to our harbor engineers, a fair degree of success has been attained, largely empirically. Putting aside for the moment the question of the quality of the cement, over which they had little control, they understood in some degree that the concrete must be strong and dense, and, by proportioning the aggregate, obtained a material which complied fairly with these requirements. But accurate measurement of voids and the knowledge that ordinary good concrete of about 1:6 may, and often does, contain 30% of voids, have not been so generally utilized as to prevent failures which are traceable to erosion and corrosion by the sea. It is not enough that a block of concrete should be strong; it must be as nearly as possible impervious and impenetrable. The need for these qualities in reinforced concrete is vastly more urgent; reinforced concrete has a vulnerable skeleton, and its exoskeleton must be perfect. Fair wear and tear is only a mild case of external mechanical violence, and need not be further considered.

A particular form of external violence is the action of fire in any serious conflagration. It has been frequently stated that concrete structures are substantially fireproof, and, as far as inflammability is concerned, this is true, but it must be remembered that set cement is a substance containing combined water and carbonic acid, and that these are expelled at a comparatively moderate temperature. It might be naturally supposed that a structure exposed to fire would be seriously weakened by the decomposition of the essential cementitious constituents, and this surmise is, of course, correct. But, for all that, the amount of deterioration is less than one would think likely, and the appended table shows the results of a few experiments made on a cement mortar in the usual proportions of 3 to 1 by weight.

Test pieces* were heated for 1 hour at the following temperatures:—

Temperature Cent.	% Loss calculated on cement.	
100	5.32	No appreciable effect.
200	14.12	No appreciable effect.
300	16.68	No appreciable effect.
400	16.56	No appreciable effect.
500	17.06	No appreciable effect.
600	21.92	Sound—weak at edges.
700	22.24	Sound—friable.
800	25.08	Sound—distinctly friable.
900	25.08	Sound—distinctly friable.
1,000	24.36	Sound—very weak.
1,100	25.40	Sound—very weak.

*Composition of test pieces, 3 standard sand to 1 Portland cement by weight. Age 3 months.

In no case, even at the highest temperature, were there any signs of disintegration or flying, and no mechanical loss occurred during the test.

It will be seen that up to a temperature of 500° C. there is no appreciable alteration, and even beyond that the test pieces show considerable stability, a circumstance which is reassuring from the point of view of that most important question of fireproof construction. Before accepting such a conclusion unreservedly, however, it must be remembered that the tenderest members of reinforced concrete are the steel reinforcements, and that if the heat penetrates the envelope of concrete sufficiently to soften the steel, the destruction of the building will occur exactly as in the case of an ordinary steel frame building.

Shortening of the life of concrete by chemical action of external origin, which for the purpose of a list have been put under three headings, may be conveniently considered under one. A great number of investigators have applied themselves to determine what is the probable or presumptive life of concrete, and, on account of the practical importance of the problem, have chiefly concerned themselves with the action of one saline solution. The destruction of concrete by seawater has always been, since the days when Portland cement first began to be used, a matter of much concern to engineers engaged in maritime works, and, even as lately as 30 years ago, much confusion of mind existed. Thus, because magnesia was found to be a predominant constituent of various incrustations and exudations on sea work, the erroneous conclusion was drawn that it was derived from the cement, and anxiety was felt concerning what could be considered the permissible limit for magnesia in cement. Of course, it is now common knowledge that the magnesia found has been formed from the seawater by the action on it of the lime of the cement, and that the small quantities of magnesia normally present in Portland cement of good quality are without influence in these cases of injury.

It may be accepted that the heaviest and most important work is block work, and in this case the cement has ample time to harden before it is exposed to the sea. From consideration of expense, it is sometimes desired to use a comparatively poor mixture, but the saving is sometimes dearly bought. In fact, the one indispensable condition for a long life for work exposed to the sea is the denseness and imperviousness of the concrete, and this is difficult to secure unless the cement is used liberally. It is impossible to fix a proportion, as that will depend on the aggregate. Every case must be judged for itself, the voids determined experimentally and enough cement used to fill them. Whenever any good form of puzzolanic material, such as trass and the like, is available it should certainly replace a part of the sand, for its use in forming a calcium silicate with the lime, normally set free during the setting of Portland cement, is undoubtedly of value, much conducing to the obtainment of that imperviousness which is a necessary condition for sound and lasting work. It should not be overlooked that any puzzolanic material can fulfil two functions. If coarsely ground, it acts partly as an aggregate like sand, and it is only when ground as finely as the cement itself that its full activity as a cementitious material comes into play. There is no objection to the use of coarse puzzolana if the supply is abundant and local, but, if it has to be brought from a distant place, it is evidently uneconomical to use part of it for a purpose equally well fulfilled by an inert material like sand. In some cases, it might be desirable to grind the puzzolana and cement together to an equal fineness. This plan has been objected to by many engineers as being equivalent to an adultration of the cement, but this view is mistaken if the mixture is sold under its old name, and the proportions

of the two materials are stated. Many laudable attempts have been made to obtain imperviousness by the addition of the most various materials, such as barium salts, soap and fatty or mineral oils, but, though some of these are of value under special circumstances, they have not as yet shown themselves suitable for the heavy sea-work now being dealt with; at present there is nothing better than ordinary concrete made with most carefully chosen and graded aggregate, with the addition of trass if local conditions allow, and an ample proportion of cement. Concrete made thus can only be attacked on the surface, and its destruction by percolation is well-nigh impossible. To state its probable length of life would be a rash attempt; it should last indefinitely, in fact, until the harbor or other marine work had become obsolete.

When concrete has to be cast *in situ* opportunity for setting undisturbed is sometimes but poor, as compared with that of blockwork, but the same principles hold good, with the one addition that the setting time should be the minimum which will allow the material being got into position without disturbing or working it after setting has begun. Seawater is by far the most abundant saline solution, and contains those salts, magnesium salts and sulphates, which are most harmful to cement. What has been said of it applies to most other saline solutions which are likely to be harmful, and the precautions already mentioned apply in such cases. Of course, there are special instances of injury by such salts as sulphate of iron or the mixed metallic sulphates found in mine waters, but the nature of their attack is similar, and they are of too special a character to warrant more than mention in a paper dealing with the life of concrete structures in general. There is a common belief that salts in the act of crystallizing may expand and thus injure a structure of which they occupy the interstices. The amount of expansion of three typical, easily soluble salts have been determined as follows: (1) Supersaturated solution of sodium sulphate—Expansion on crystallizing, 1.45% by volume. (2) Saturated solution of magnesium sulphate—Contraction on crystallizing, 0.14% by volume. (3) Supersaturated solution of sodium thiosulphate—Contraction on crystallizing, 0.37% by volume.

Mr. Blount is of the opinion that much importance need be attached to the view that concrete is injured materially by the crystallization of salts in its crevices, for the crystals—even when they do connote an increase of volume—are mechanically weak, and can exercise but little disruptive effect. It is the chemical action of saline solutions which is to be feared and guarded against.

Destruction of concrete by acids, and by this term acid salts are included, stands on a different footing. Obviously, strong acids turned to waste from a chemical works will destroy so calcareous a material as cement, and if the acid is sulphuric acid, destruction will proceed after the acid has been neutralized. But there are less obvious, though very real, causes of destruction. Many putrescent matters, such as sewage, will give off gases containing sulphur, and these, under suitable conditions, will oxidize and produce sulphurous acid, and, ultimately, sulphuric acid; or, alternately, will form sulphides, such as calcium sulphide or ferrous sulphide, which in due course, oxidize to the corresponding sulphates and injure or destroy any cement with which they may come in contact. It has been observed that with sewage of this kind flowing through concrete pipes the invert may be unaffected, while the arch is seriously attacked. The explanation generally accepted is that hydrogen sulphide, or some gaseous organic sulphide, is generated from the liquid, and coming in contact with the upper part of the pipe forms sulphides, which are oxidized to sulphates by the air above the level of the liquid. As the source of the sulphides, and therefore of the sulphates, is continuous, attack by the latter proceeds, with the result that the part of the pipe which is not immersed may suffer severe corrosion. It is impracticable to prevent access of air and to turn the whole sewer into a septic tank, and the only reasonable course is to use some other kind of pipe where the conditions mentioned are known or suspected, or to face the expense and trouble of occasional repairs.

Closely connected with corrosion of concrete by acids, actual or potential, is attack by electrolysis. All cement contains a small quantity of alkali, and this is an excellent electrolyte and will serve to convey such a current as may be straying from a lighting or power circuit. Instances have been recorded of destruction of concrete by such stray currents, and in this case, again, prediction of a probable life of the structure is clearly impossible. But stray currents are not in the same category as wind and wave and earthquake and their divagations should be prevented by proper insulation. To regard them as inevitable, like the rain, is not the attitude of mind of the electrical engineer, and it is to him that we must look for prevention. Suggestions to make the concrete waterproof, where there is a possibility of electrical leakage, are, however, well worth consideration, and in such cases, which should be rare, a sheath of some asphaltic material, such as is used for damp-proof courses, would be serviceable. But it cannot be too clearly said that this is the wrong principle to go on; it should not be necessary to protect concrete from stray currents, because those errant currents should be kept in their narrow channel.

The quality of cement for reinforced concrete must be at least as good as that for ordinary concrete, and, if possible, should be better. This is not because the latter should not be as near perfection as the maker can achieve, but because Portland cement for reinforced concrete is, as it were, a pioneer of progress, and what is a special brand for such purposes to-day will be the ordinary commercial article to-morrow. Turning to steel, one may say that no better example of the advantage of that scientific direction which is now applied to Portland cement could be found than in the case of the steel, and it is significant that the metal, the more difficult of the two to manufacture, was being made of good and uniform quality before chemical principles were recognized and acted on in the manufacture of Portland cement. Thanks to the fact that for some forty years the regulation of the composition has been in the hands of the chemist, little is left to be desired in the modern commercial product. Of course, cases have occurred, and will occur, of careless manufacture and inspection where brittle and inferior material has found its way into the work, but they are not numerous and only rank with such failures as arise in all structures. Good as modern mild steel is, it may be properly asked whether, in some cases at least, steel of a higher grade and greater tensile strength may be advantageously used. This applies to ordinary structures and is, of course, obligatory for such buildings as safe deposits where the metal must not only have a good tensile strength, but be so hard as to be practically undrillable.

Turning now to reinforced concrete one may say that all the causes of attack, and consequently shortened life, which have been discussed under the heading of ordinary concrete, are valid equally with reinforced concrete, and, in addition, there are some other causes peculiar to reinforced concrete. In practice, the reinforcement consists of steel in some form, and is subject to the same corrosion as steel in other structures. By a very fortunate circumstance, cement is an alkaline substance and the metal, iron, in an alkaline medium does not rust. These com-

forting facts do not warrant the deduction that the steel reinforcement is immune from corrosion. That is true only if it is completely enclosed with concrete which is fully in contact with it and is free from fissures, a cogent reason for the use of concrete, for reinforced work, of a higher grade than that generally necessary. It is highly desirable that the concrete should not only be without fissures, but should be impervious. The advantages in preventing the percolation of any saline or corrosive substance are so great that the extra trouble and cost are well repaid.

Regarding the conditions which influence the stability of reinforced concrete, it is highly desirable that a full set of tests should be made to obtain reliable data on two points, *viz.*, rate of percolation and alteration of strength of reinforced concrete; and, in both cases, the test pieces must be prepared by an operative accustomed to such work, and carrying it out as it would be carried out in practice under proper supervision. No reliable data obtained by experiment, as distinct from observation, are extant, showing whether reinforcing steel will corrode; and here again, a full set of tests should be made. Casual observations of the condition of the metal in reinforced concrete which has been exposed to severe natural conditions are of the utmost value, but we want something more than that. We want definite facts which will tell us what is the prospect of life of reinforced concrete properly and carefully, but not meticulously, made, when it is exposed to the most drastic conditions which it will be called upon to endure in practice; and one of the governing factors is the non-rusting of the steel. In matters of this material importance, it is not sufficient to come to a conclusion on general principles alone, but these must be used in conjunction with experimental data as accurately obtained and obtained over as long a period as practical requirements allow. It is true that long-time tests may be useless and obsolete before their term is out, 20 years, 50 years it may be, not much in the life of a structure, but the trouble and cost of making them is trifling, and sometimes their results are priceless. Let us build for posterity in this matter; it is easy for them to discard our juvenile ideas, but now and then they may find something good. With the knowledge of this date, it seems fairly certain that little fear need be felt of steel reinforcement rusting when well embedded in good non-pervious concrete of adequate thickness, even when the structure is exposed to seawater or other saline solutions, but the case is altered when the concrete is exposed to electrolysis. As has been mentioned above, cases have been observed of the destruction of ordinary concrete by electrolysis, and the risk of injury to that is small compared with the likelihood of destruction of reinforced concrete by the same cause. The advantage of an alkaline medium may disappear, and the steel reinforcement serving as a positive electrode may be attacked by all the negative ions of the electrolyte. Corrosion will be rapid, and the stresses exerted by iron rusting are known to be large, though they have never been computed. It must be remembered that it is not necessary for there to be a direct electrical leak from the inside to the outside of the concrete. Wherever the current flows there must be a drop of potential, and as the joints between the metallic members are electrically poor, it is certain that at all those points corrosion must occur. In a modern structure honeycombed by electric leads, most serious results may occur from such unsuspected cause, and the mischief may be wrought secretly and effectively, quite nullifying any reasonable presumption of the life of the structure.

There is another fact which tends to limit the life of a structure made of reinforced concrete. One of the great advantages of this material is its homogeneity. A properly designed and made structure is as much of a piece as if it were a casting, and, like a casting, experiences internal stresses. These can be minimized or provided for by careful design, but there is no process equivalent to annealing by which they can be removed. Instances are on record where cracking has happened in long continuous lengths or in large thin walls or panels, which, assuming material and work to be free from fault, must have been caused by internal stresses. There is always some stress, and the amount may be increased by part of the structure being wet and another part dry, and it is just on this point that very little exact information is available. Because, by a happy accident, the co-efficients of expansion of steel and concrete are nearly identical, it has been too hastily assumed that stresses between the two are negligible, the fact being overlooked that wetting steel has no effect on its size, and wetting concrete has a well-marked effect. Thorough investigation, using large test pieces over a long period and under perfectly determinate conditions, would be of the utmost value, and would afford us data superseding the somewhat casual observations on which too much reliance has hitherto been placed.

That this knowledge is of much more than academic importance will be admitted when the construction of dams in reinforced concrete is considered. In a dam, every element of destruction of the kind which has been discussed must be studied and prevented. The concrete must be watertight, for any percolation through pores or cracks will be much more injurious than a similar leakage through an ordinary concrete or masonry dam. The very core of the structure will be attacked, and its ruin is only a question of time. The fact that a dam is a monolith, and may be a huge one, with a crest which is slim and delicate compared with the base, and that it lies, as it were, between wind and water, wet on one side, dry on the other, with a fluctuating height of wetness and a varying load, enforces the absolute necessity of knowing precisely what internal stresses must be met.

Of all the causes of destruction, by far the most important is corrosion by saline solutions, and it is the most insidious, as the structure exposed to the action of the solution—whether a harbor or a sewer—may be covered by the attacking liquid, and difficult to examine. For such structures, impermeability is imperative. Reliance on any form of silting up, taking up, covering by organic growths, is mere lazy folly. The material must be free from interspaces which are not microscopic and disconnected. Anything approaching a channel is undoubtedly mischievous, and may be fatal. This axiom has been arrived at painfully and with heavy cost in the hard school of experience before reinforced concrete was thought of, and is doubly axiomatic—if one may be pardoned the term—when the concrete has in its heart a more sensitive core, protected, it may be, by a layer only two or three inches in thickness. The permanence of concrete depends on its imperviousness, and that any condition which limits this limits its life almost *pari passu*.

All other causes which tend towards destruction sink into insignificance beside this, but for all that they must not be ignored. The next worst, closely approaching the severity of attack of saline solutions, is the injury caused by aggregates of the class of coke breeze, containing sulphates of potential sulphates. From the very nature of the material, and from the use to which it is put, namely, to make light floors, ceilings and partition walls, it is clear that it cannot be impervious, and it follows that whatever water reaches one of its surfaces will speedily make its way to the interior. Where water can go, air can follow, and the assumption that sulphides are fairly harmless falls

to the ground, because they are in the most favorable condition to become sulphates, and the fate of the structure is then settled.

Next in order of sinister magnitude is the injury caused by electrolysis. It is true that the cases recorded are at present few, but it must be remembered that the transmission of large currents at high pressures is a comparatively modern thing, that large structures of reinforced concrete are comparatively modern things, and the most progressive spirits cannot hope to see buildings only five years old fall like the walls of Jericho. It may soothe their natural impatience to reflect that although the structures and the electrical power are fairly new, yet human blundering is fairly ancient and to be relied on, and on that ground alone, it is reasonable to suppose that failures induced or exaggerated by electrolytic action will become fairly common, particularly when there is a steel core to attack and an electrolyte additional to those alkali salts which naturally occur in any normal cement.

It has been necessary to indicate all those causes of injury for destruction which are to be reckoned with as affecting the life of concrete structures made with modern cement, and the impression conveyed may be that all such structures are so liable to decay as to be almost ephemeral. The conclusions to be drawn, however, are these: First, that there exist causes of destruction, internal and external, which, if uncontrolled, will certainly destroy any structure, even when its design is impeccable, and that its life is at the mercy of these causes, and though its death may be lingering, it is certain. Second, that all such causes, except extreme external violence, can be controlled, and their effect nullified by knowledge, care, and skill exercised in the directions mentioned and discussed above; and, as a necessary result, by the practical elimination of nearly all these attacking forces, security and something like permanence will be attained.

GRADATION OF ROAD TRAFFIC.

THE report presented at the annual meeting of the Canadian Society of Civil Engineers last week by the standing committee on roads and pavements, contains an appendix relating to traffic gradation, that is as follows:—

Traffic is not only to be regarded from the standpoint of total tonnage, per foot of width of pavement or roadway; but also from the standpoint of predominating class of vehicle, speed, and maximum weight of vehicle, etc. An analysis of the various forms of traffic may be made as follows:—

Horse-drawn steel tires.	Pleasure vehicles.	Single horse.	
		double or pair.	
	Farm or commercial vehicles.	Single	Loaded.
			Not loaded.
		Double	Loaded.
			Not loaded.
	Extraordinary.	Quarry, brickyard or other regular and destructive traffic.	
Self-propelled rubber tires.	Pleasure vehicles.	Less than 7-seat motor.	
		Seven-seat or over.	
	Commercial trucks.	Loaded.	
		Not loaded.	
	Extraordinary.	Motor bus or other special traffic.	
Self-propelled steel tires.	Steam lorries and tractors, with trailers, etc.		

The conclusions from a traffic census as to unit weight and other details can be only approximate. Refinement in traffic census might be difficult for many town or city engineers to obtain, and might defeat the aims of the committee. A general and simplified classification is therefore under consideration, which may be briefly expressed, for which purpose the following is suggested:—

1. Horse-drawn steel tires.	A. Light vehicles	(1) Light—up to 100.
		(2) Medium—100 to 200.
		(3) Heavy—200 up.
	B. Heavy vehicles, wagons, trucks.	(1) Light—to 75.
		(2) Medium—75 to 150.
		(3) Heavy—150 up.
2. Self-propelled rubber tires.	C. Passenger automobiles.	(1) Light—up to 100.
		(2) Medium—100 to 400.
		(3) Heavy—400 to 800.
		(4) Severe—800 up.
	D. Motor trucks and busses.	(1) Light—up to 10.
		(2) Medium—10 to 20.
		(3) Heavy—20 up.
3. Self-propelled steel tires.	E. Steam lorries and tractors.	(1) Light—1.
		(2) Medium—2 to 6.
		(3) Heavy—6 up.

In the description of traffic, the various factors of the foregoing schedule may be indicated by letter and number thus: A (3) + B (2) + C (2) would mean "Light vehicles, heavy traffic + heavy vehicles, medium traffic + passenger automobiles, medium traffic."

The method of using this notation is indicated by its application to treatment of various road surfaces for dust prevention. In the following schedule, Column (1) shows the surface material considered; Column (2) shows the maximum traffic for which such surface would be applicable; and Column (3) shows a suitable treatment for dust prevention in each case. (It is to be understood that this schedule has not been finally adopted by the committee as a standard for dust prevention, but is submitted for explanatory purposes in connection with the proposed notation for traffic gradation.)

(1) Surface material.	(2) Maximum traffic on which it can be considered.	(3) Treatment for dust.
1. Sand	A1 + B1 + C1	Asphaltic oil, hot application. Calcium chloride.
2. Gravel	A2 + B2 + C3 + E1	Asphaltic oil, cold application.
3. Gravel	A2 + B2 + C3 + D1 + E1	Bituminous penetration or mix.
4. Broken stone, soft, water-bound	A2 + B2 + C2 + D1 + E1	Oil, paraffin base.
5. Broken stone, soft, water-bound	A2 + B2 + C2 + D1 + E1	Asphaltic base, cold.
6. Broken stone, soft, water-bound	A2 + B2 + C3 + D1 + E1	Asphaltic base, hot.
7. Broken stone, soft, water-bound	A2 + B2 + C3 + D1 + E1	Tar, cold.
8. Broken stone, hard, water-bound	A3 + B2 + C3 + D2 + E1	Bituminous.
9. Broken stone, hard, water-bound	A3 + B3 + C3 + D2 + E2	Bituminous concrete or penetration.
10. Concrete	A2 + B2 + C3 + D2	....
11. Vitrified brick stone setts and wood block	A3 + B3 + C3 + D3 + E3	....

MASONRY DAMS.*

By Arthur P. Davis and D. C. Henny.

THE remarkable progress of the last few years in the application of science to the uses of man has extended to the design and construction of dams. The wide range of experience covered by recent practice in this branch of engineering affords an extensive field of study and an inexhaustible mine of information.

The progress of sanitary science, demanding better and more generous water supplies for rapidly growing urban population; the wonderful growth of water power development; and the demands of irrigation and flood control have all performed their parts in stimulating the construction of dams of all classes; and the large number of such structures recently build have led to the evolution of ideas and theories that inevitably accompanies important experience.

The two great classes of dams are those of masonry and of earth, which, though fulfilling identical functions, are so different in character and construction as to require widely different treatment both in theory and practice. Between these two distinct classes, the rock-fill and the combination of earth and rock-fill constitute a third class partaking more or less of the characteristics of both the main classes.

For a logical treatment of the subject, it seems best to ignore the purpose of the structures. While this may at times exert some influence on design its effect is generally not of a material character. The more natural division already mentioned refers to the material of construction, generally dictated by considerations of foundation and materials available.

Up to 30 years ago, only one general type of masonry design had been carried out in America, namely, mass masonry, depending for stability against water pressure on weight of material.

The most favorable disposition of material was determined upon the assumption that tension in masonry should be avoided, leading to the requirement that at any horizontal plane the resultant of all forces should fall within the middle third. The theoretical section, considering water pressure alone, thus became a rectangular triangle, with its apex at maximum high-water level, a vertical water face and a downstream slope of approximately 2 to 3, dependent on the specific gravity of the masonry. This theoretical section was then adjusted to the constructural necessity of providing top width and the limitations assumed for permissible compression stresses in the dam itself and on the foundation. In some cases, ice thrust was assumed in addition to water pressure. Examples of this type of dam are the old and new Croton Dams and the Ashokan Dam of the New York Water Department, the Wachusetts Dam for the supply of the Metropolitan District, including Boston, the Elephant Butte Dam of the United States Reclamation Service near El Paso, and numerous others. These dams are all intended for water storage and are not subject to overflow, independent spillways being provided to pass flood waters.

The same type, with the addition of an apron, is very commonly used in diversion dams, as in the case of the Granite Reef Dam, near Phœnix, Ariz., the Bull Sluice Dam near Atlanta, Georgia, and especially the Le Grange Dam, near Modesto, Cal., the latter having a height of 100 feet. The Boonton Dam, near Jersey City, is an example of a dam which for part of its length acts as a spillway.

* From a paper on "Dams," presented at the International Engineering Congress at San Francisco.

Mr. John D. Van Buren, in 1895, pointed out the danger of sliding to which dams of this type are subject, if approximately horizontal cleavage planes exist in the masonry itself, or in the foundation. The upward pressures in such planes tend to reduce the pressure of superstructures upon foundation, upon which resistance to sliding is largely dependent. The failure of the dams at Austin, Texas, and at Austin, Penn., illustrates this danger. An increase of section and weight was therefore proposed to meet this danger, the extent of which can be only surmised, as it is dependent on factors difficult or impossible to determine. The San Mateo Dam, near San Francisco, was designed to resist uplift under its entire base, equal to the hydrostatic head, reservoir full.

This involves the assumption that cleavage planes can exist in which there is no point of contact between the over and underlying strata, and yet these bodies are so close together as to confine the leakage and produce full uplift. This condition is, of course, impossible and can hardly be approached in practice. Various compromises have been proposed, all either involving some diminution of pressures near the downstream slope, or making reduction for areas in contact. The Olive Bridge and Kensico Dams of New York City Water Supply were designed on the theory that upward pressures would occur equal to full head of full reservoir on the upstream side, and full head of ground water on the downstream side, the head varying uniformly between these limits.

Natural conditions vary widely, but it is not safe to assume any foundation to be entirely impervious. The determination of the perviousness of natural formations is one of the most difficult things in nature. Any examination of such formations which disturbs them, changes the conditions which it is desired to ascertain; for this and other reasons, it is necessary to allow a large factor of safety in any estimates which involve this factor.

In general, it may be said that water will more readily follow seams or bedding planes than devious paths through the material of the rock. It follows that it will pass more readily and in larger volume in the direction of stratification than in a direction normal thereto. Similarly, stratified rock will permit percolation more easily and in greater volume than good massive rock, such as granite.

Granular rock, such as sandstone, is likely to transmit more water through the rock itself than one of denser or finer grain, such as limestone or shale, but no exact rule of this nature can be laid down, because there are many varieties of each kind of rock with various percolating capacities. In general, however, the following rules may be taken as a rough guide:—

1. Massive or crystalline rocks, such as granite, gneiss and schists, will transmit water less freely than those of sedimentary origin.

2. Stratified rocks will transmit water much more readily in the direction of stratification than transversely thereto.

3. In the direction normal to stratification, sandstone will generally transmit water more readily than limestone, and the latter more readily than shale.

4. Stratification on a plane approximately horizontal is the worst possible condition for introducing upward pressures beneath a dam. Conversely, the most favorable position in this respect for stratified rock is in vertical beds.

Avoidance of tensile stresses in the water face of a dam is clearly of the utmost importance in connection with uplift pressures, since cleavage planes might otherwise be formed at the point of greatest danger. Some interesting experiments with small models of dams made of flexible

material indicate that even with the resultant falling within the middle third, tensile stresses are liable to exist at the heel of the dam. The existence has also been alleged of severe shear stresses, such as would materially reduce or neutralize supposed factors of safety.

The success, however, of so many of the dams of ordinary gravity type where no distinct cleavage planes exist in the foundation material, makes any large addition to the triangular section seem unwarranted. Moreover, other and more economical means suggest themselves for overcoming danger of sliding, the foremost of which has been the adoption of a plan for the dam curved upstream instead of straight. Each portion of the dam remains self-supporting by its own weight as to horizontal water pressures, while arch or wedge effect will develop in case of tendency to slide. Its application generally involves but a moderate additional mass, where the dam is relatively short. The Furens Dam in France, the Cheesman Dam in Colorado, the Roosevelt Dam in Arizona, the East Park Dam in California, and the Arrowrock Dam in Idaho, illustrate this principle. The Sweetwater Dam in California, as originally completed in 1895, is an example of a dam in which, considered as a gravity dam, the resultant with reservoir full strikes outside the middle third, and in which the arch effect due to its curved plan is depended upon to prevent tension near the water face. It was, however, enlarged in 1911, as a gravity structure.

Uplift pressures being due to penetration of water can be reduced or prevented by increasing the density of the masonry near the water face, by surface treatment of this face, and by deep cut-off and drainage. All these means are now being employed, as, for instance, in the case of the Elephant Butte Dam, New Mexico. The concrete masonry, for a depth of 10 feet from the water face, is extra rich in cement, the face is given a one-inch mortar coat with a cement gun, the cut-off wall at the heel has been carried to a great depth (Max. 100 feet below river water), and the method of grouting under pressure is employed to 50 feet greater depth. Downstream from the plane of closure, drainage wells have been provided in the masonry and drilled in the foundation to dissipate pressure of seepage water. Similar precautions have been taken at the Arrowrock Dam, Idaho, which, moreover, is built on a curved plan.

Another method for reducing uplift pressure is used in the case of low diversion dams built on water-bearing material, as, for instance, the Grand River Diversion Dam, Colorado. This consists of a concrete blanket or apron extending upstream from the heel of the dam, with cut-off wall at upstream edge. The effect of such apron is to lengthen the path of percolating water, thereby reducing the upward pressures under the dam, which, moreover, is given added weight to resist the estimated remaining uplift. The same effect has been aimed at in puddle-fill on the water side, which method appears to have been more common in Europe than in the United States.

It is apparent that the natural process of silting, where water carries silt, will aid in reducing upward pressures, the artificial means, in case of silt-bearing water, being especially intended to obviate danger during the earlier years.

In low dams constructed of wood, it has for a long time been customary to provide a water face with a rather flat slope, resulting in a vertical water load on the foundation which would tend to resist sliding. This type of dam has been copied in reinforced concrete for structures of considerable height. Near Douglas, Wyoming, a reinforced concrete dam of this type has been built for storage purposes, having a total height of 130 feet. A portion of this dam is adapted to overflow as a spillway. A notable overflow dam of this type is the Clackamas Dam, 70 feet high, recently built near Portland, Oregon.

The water slab is supported by buttress walls, which afford a relatively long base up and downstream, imparting great safety against tensile stresses (except in the reinforced slabs themselves), and also rendering it economically practicable to reduce foundation loads either by spreading of the bases of buttress piers or by placing them on a continuous concrete floor. It is essential that such floor be provided with weep holes to eliminate upward pressures.

The low foundation pressures which can thus be economically secured render this kind of dam practicable on gravel foundations, provided a deep cut-off connects with the water face slab or the latter be extended upstream in the nature of an apron. Dams of this type have also been built on clay foundation, slight settlement being immaterial in view of possibility of sliding adjustment between abutments and water face slabs.

The facility with which construction of this kind of dam will permit handling of flood flow during construction is obvious and valuable.

This type of dam has also been executed in steel, as in the cases of the Ash Fork Dam in Arizona, and the Hauser Lake Dam, Montana. The latter dam failed, but its destruction is believed to have been due to insufficient cut-off and piping, part of it having been founded on gravel, and is in no way to be attributed to the substitution of steel for reinforced concrete.

Dams to be constructed in relatively narrow canyons invite consideration of the use of the arch principle, not merely as a safeguard against sliding, but as the chief means of resisting horizontal pressure. The famous old Bear Valley Dam, California, now made useless by the construction of an arched gravity dam a short distance downstream, furnishes the boldest example of this type, in which arch pressures may have existed of over 70 tons per square foot. More recent instances are the Pathfinder Dam, Wyoming, and the Shoshone Dam, Wyoming, of the United States Reclamation Service, the dam near Ithaca, New York, and a number in Australia. The safety of these dams depends upon unyielding abutments and limitation of arch pressures. These pressures generally range between 15 and 30 tons per square foot. Danger from sliding due to upward pressures is absent. The division of load between the arch and the cantilever introduces secondary stresses the nature of which is as yet not thoroughly understood.

Dams of this type are usually protected from overflow by independent spillways. The Huacal Dam, in Mexico, has but a partial spillway protection and may at times be overtopped, for which reason an auxiliary low dam was built downstream to form a water cushion and protect the foundation.

All the above dams are arched to a radius, which remains constant from foundation to top. Considerations of economy have led to a design with a variable radius and as near as feasible constant circumscribed angles. The principle has been developed by L. R. Jorgensen, Mem. Am.Soc.C.E., who shows that a considerable saving of masonry may, under favorable circumstances, be effected, and has been applied in the Salmon Creek Dam, Alaska, and the Lake Spalding Dam, California, and on a smaller scale in the Clear Creek Dam, Washington, which latter is also an overflow dam. It may be stated as a matter of historical interest that the original Bear Valley Dam was built with a shorter radius in the lower part than in the upper.

A series of vertical arches supported by buttress walls was used as a low spillway dam in connection with the

East Park Reservoir, California, for purposes of economy and lengthened spillway crest.

The principle of the inclined face dam with buttresses has been successfully used recently by substituting arches for flat slabs, resulting in the multiple arch type. This permits avoidance of beam tension in the closing curtain and obviates the necessity of dependence upon concrete embedded steel, the life of which, in saturated concrete, is as yet a matter of uncertainty. A diversion dam of this type was built on the Umatilla River in Oregon, and a storage dam with a maximum height of 61 feet at Hume Lake, California. A singular example of this type of dam occurs on Lost River near Klamath Falls, Oregon, where a plan in the shape of an elongated horseshoe was adopted to give the desired length of overflow so as to avoid submergence of valuable land in times of freshet, and to provide a basin for receiving the overflow water.

Contraction Joints.—The reinforced and multiple arched types naturally contain numerous contraction joints. Such joints were introduced in the Ashokan, East Park, Arrowrock, Elephant Butte, and other gravity dams. Dams of the pure arch type have, however, been generally of monolithic construction, the need of contraction joints being less marked by reason of greater flexibility of the general body. No cracks have been so far observed in the Pathfinder Dam. The Shoshone Dam shows a very slight crack near the top at each abutment.

Contraction cracks being objectionable from the standpoint of ultimate life, as well as appearance, many dams are now provided with contraction joints for a part of their height. These are placed from 100 ft. to 50 ft. apart, and near the top sometimes closer. They are provided with one or more keys and at times with a metal water stop, and usually with a drain back of the closure. These joints permit shrinkage due to setting, as well as to temperature effect, and tend to reduce secondary stresses. They do not seem objectionable in any way, except in requiring more form work. The work can be laid out so as to construct the alternate sections, at least near the top, at a time when contraction is at a maximum.

Material.—The material used in masonry dams has been coursed masonry throughout, rubble masonry faced with coursed masonry, using ordinary mortar or concrete mortar in connection with very wide joints, coursed masonry faced with concrete interior, and all concrete with or without plumstones. The use of concrete has been growing in favor. It can be laid mainly by machinery, and is economical in many locations where good rock is not available. The economy of its use has recently become more marked through improved processes of mixing and depositing. It requires, however, more cement than rubble masonry, which, where distance of cement haul is an important factor, may render the latter at times the cheaper.

The New York Board of Water Supply has built two dams of concrete, faced on both sides with concrete blocks laid in mortar. These block faces serve instead of forms, and as they can be cast while foundations are in preparation and in all kinds of weather, they tend to expedite construction. Their chief virtue, however, is their appearance.

Portland cement is now universally used in mortar and concrete and is shipped from commercial mills. The mass concrete is generally proportioned 1 : 3 : 6, the aggregates being crushed rock or gravel tested for minimum voids. In some cases Portland cement has been ground locally with sand (sand cement) in proportions varying from 40% to 50% of the mixture. This material was largely employed on the Arrowrock and Elephant Butte Dams, in order to reduce the proportionate cost of cement. It sets more slowly, however, and forms are therefore more costly per cubic yard, as they cannot be removed as soon as with normal cement concrete. This tends to reduce the saving due to reduction in pure cement. A like result follows from the tendency to increase the proportion of sand cement, as compared with normal Portland cement used in the mixture. There has also been observed greater liability of damage to surfaces from frost, probably due to slow hardening. The tests with concrete blocks show a slightly reduced strength, but indicate no reduction of strength with age and a strength ultimately equal to that of straight Portland cement. It is only on work of great magnitude, where freight items are large, that any saving can result from the use of this material.

The concrete with either Portland or sand cement is usually mixed sloppy, water being carefully limited, however, so as to avoid excess. This consistency permits distribution from towers and through pipes. It is worked by shovelling and man-kneading so as to make it as homogeneous as feasible and to release contained air. Spades are used next to the forms to insure sound and tight surfaces. The tendency to the formation of smooth surfaces between old and new work is counteracted by wire brushing and by imbedding plumstones.

Cement Made Locally.—It is the universal custom to transport Portland cement to the locality. An interesting exception is the case of the Roosevelt Dam, in Arizona, where the distance from the nearest railroad point was 60 miles, with mountain roads intervening. Suitable materials for manufacturing cement were found near the site and local manufacture caused a saving estimated at over $1,000,000 in the construction of 360,000 cubic yards of masonry.

Movable Dams.—The use of movable dams has been steadily increasing to meet conditions under which it is necessary to maintain a relatively constant water level under fluctuation, flood or changeable uses of water. Devices for such use are very numerous. The various forms of wickets and shutters have been long in use in Europe and America with a fair degree of success. The more recent bear trap, to be operated by water pressure, has had several modifications and has been frequently employed.

The Stoney sluice gate, gliding on movable rollers to reduce friction, which is employed extensively in the great Assuan Dam of Egypt, has been adopted, with some modification, for the spillway of the Gatun Dam at Panama. It has also been employed in many other cases.

For cases in which long span is essential, the roller dam patented and employed in Europe for some years, has recently been introduced into the United States, the first installation being a small one upon the Boise River in Idaho, and several larger installations are now in progress on the Spokane River, in Washington, and the Grand River in Colorado. This, in addition to the practicability of very long span, has the advantage of simplicity, certainty of action, and a good degree of watertightness.

To accomplish the same purpose by another method, the siphon spillway has recently been introduced to this country from Europe, and used in several cases with success. Having no moving parts, it is well adapted to certain locations where there are no complications from drift, and where the volume of the fluctuation is moderate. It has the further advantage of being adapted to construction of concrete, and is, therefore, more permanent than steel or wooden structures. By various simple adjustments, a series of such spillways can be so arranged as to prime themselves automatically at different levels and thus secure any desired gradation in rate of discharge.

FIELD WATER PURIFICATION PLANT.

WHEN the Ontario troops went into camp early last summer at Niagara-on-the-Lake, Ont., many complaints were made regarding the town's supply of water. The town of Niagara-on-the-Lake has been desirous for several years of having a mechanical filter plant, because the water which they pump from the Niagara River is greatly polluted. As a considerable amount of water is used each year, however,

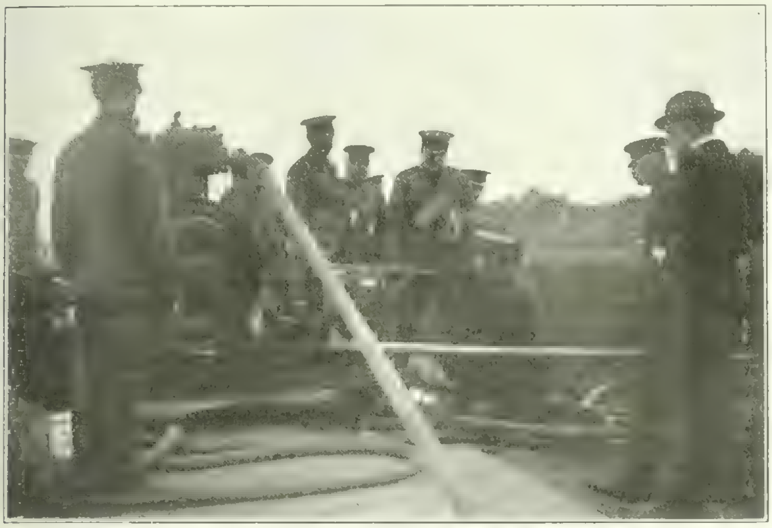


Fig. 1.—Side View of Sterilizing Outfit.

by the militia camp, the town believes that the government should aid financially in the construction of the filter plant, and, as arrangements along this line have never been made satisfactorily to both parties, the town is still using water which must be very heavily chlorinated.

To provide a better supply for the troops, a portable ultra-violet ray sterilization plant was designed and in-

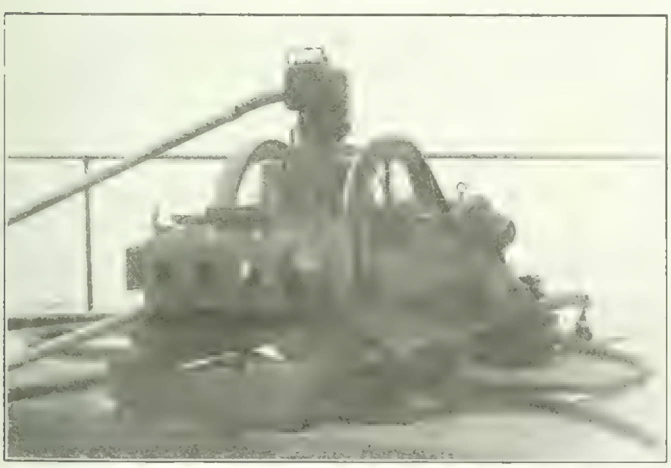


Fig. 2.—Front View of Sterilizing Outfit.

stalled by Capt. F. A. Dallyn, C.E., engineer for the Provincial Board of Health of Ontario.*

The lay-out of this plant is unique, and patents have been granted to Capt. Dallyn in regard to same, under the title of "Power Army Water Supply Outfit," and the apparatus seems to be quite adaptable for use at the front, although it is not known to what extent, if any, it is so being used.

The capacity of the plant is three thousand gallons per hour, but at Niagara it was operated at twelve hundred gallons per hour. The difference in elevation between the plant and the river level was 19 feet, and the pump overcome a total suction lift of 25 feet. The water was pumped directly from the Niagara River, a short distance above the town pumping station, the town's supply not being used at all for drinking purposes, although it was used by the soldiers for washing, etc.

The water was first passed through a mechanical filter (illustrated in Fig. 3) of the ordinary reverse flow type with high velocity wash. The water then passed through a special casting into which there were inserted three quartz tubes. An ultra-violet ray lamp was attached to each of these tubes, and the violet ray emanations reached the water through the quartz, the casting being made watertight around the quartz tubes by means of rubber gaskets.

The quartz tubes are 1½ inches in diameter, 4 inches long. One of them is shown, together with its lamp, in Fig. 5. A closer view of the part of the casting in which one of the quartz tubes is inserted, is shown in Fig. 4. A side view of the outfit is shown in Fig. 1. This photograph was taken during a trial run at Exhibition Camp, Toronto, before the equipment was shipped to Niagara. The Duke of Connaught can be seen bending over the operator's shoulder. Fig. 2 is a front view of the sterilizing outfit. Three windows will be noted in front of the casting, through which the operator can watch the operation of the lamps, the openings for the insertion of the quartz tubes being just below the windows.

The sterilizing outfit consists of the special casting and lamps previously mentioned, and of a generator, engine and pump. The current for the lamps is supplied by a 2½-kw., 220-volt, direct-current generator. The

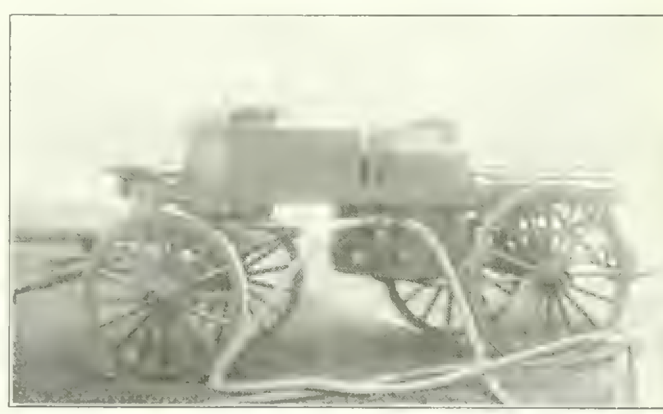


Fig. 3.—View of Portable Pre-filter.

pump is a 2½-inch Albany water-sealed rotary pump, with a capacity of three thousand gallons at 250 r.p.m. The motor is belt-driven, the pump chain-driven, and both motor and pump are driven by a 9-h.p. vertical gas engine, fitted with automatic pump lubrication, enabling it to run between 200 and 250 hours without refilling the lubricating oil chamber. The cylinder is water-cooled with connection to the discharge of the pump and overflow to waste. The

*The reader is referred to the article in *The Canadian Engineer* for December 16th, 1915, relating to the Provincial Board of Health investigations into ultra-violet ray sterilization of water.

engine has a throttle governor, phosphor bronze bearings and pump-fed carburettor. The governing of the engine is such as to give practically constant speed at all loads within its capacity.

The engine was supplied by R. A. Lister & Company, Toronto, and was built at their works in England. The generator was supplied by the Canadian Westinghouse Company, Hamilton, and the pump by the Albany Pump Company, Toronto. The lamps, quartz tubes and special casting were furnished by the R. U. V. Company, New York City. The pre-filter was built by the Thor Iron Works, Toronto, in accordance with specifications furnished by Capt. Dallyn.

Fig. 4.—Closer View of Portion of Special Casting in which the quartz tube is Inserted.

The plant was purchased by the government upon recommendation of Lieut.-Col. Marlow, assistant director of medical service, and was operated under the supervision of Capt. A. V. Delaporte, B.A.Sc., of the Canadian Army Hydrological Corps, with the assistance of M. F. Hasbrouck, of the R. U. V. Company.

An efficiency of from 99.75 per cent. to 100 per cent. was obtained during operation, as the normal count in the raw water was four thousand bacteria per c.c., and

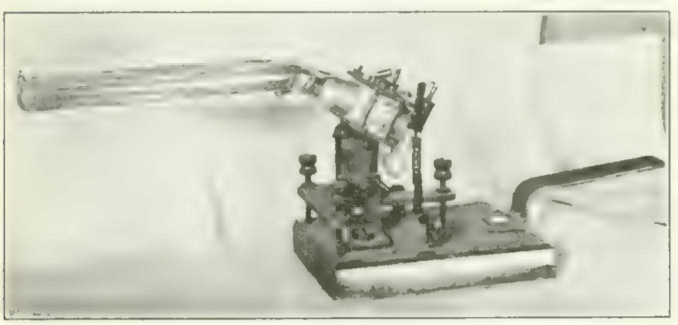


Fig. 5.—View of Ultra-violet Ray Lamp and Quartz Tube.

this was reduced to counts ranging from ten to zero. Colon bacilli were commonly present in 0.01 c.c., but after sterilization were normally absent in 50 c.c.

The Canadian Engineer is indebted for the above information and accompanying illustrations to Capt. Dallyn and to Mr. W. J. Ellis, of the R. A. Lister & Company.

A United States consular report notes the recent completion of the large tunnel on the Bagdad railway piercing the Amanus mountains, on the border between Asia Minor and Syria. It is known as the Baghtché tunnel, taking its name from the station of Baghtché, at its northern entrance, about 75 miles east of the city of Adana and some 60 miles northwest of Aleppo. It has a length of 16,028 ft.

Preliminary organization has been effected of an organization called the Cement Products Association of Canada. The temporary chairman is W. Dillane, of Kemptville, Ont. The temporary secretary is W. A. Toohey, Herald Bldg., Montreal. The membership of the association will be composed at first of concrete pipe manufacturers. Standard specifications will be adopted, and all who wish to join the association will be required to live up to these specifications in the manufacture of their pipe.

THE BUSINESS SIDE OF ENGINEERING.

A weak point in the engineers' professional armor was mentioned by Mr. A. E. A. Edwards recently in his presidential address to the Birmingham Association of Mechanical Engineers.

Three features of an engineer's training, he said, did not usually receive sufficient attention—the commercial side of the business, the control of men, and the power of speech. There were doubtless others, but there they had three features which were essential to turn a sound technical man into a successful engineer, and there were numbers of men absolutely sound technically who would be at or around the top of the tree if these three points had been more fully developed in them, even at the expense of a great deal of their technical work.

To put the matter in a nutshell, an engineer is usually taught the profession instead of the business of engineering. In his opinion, if a firm undertook to teach an apprentice engineering they should be expected to give him some knowledge of the commercial side of the business, for that was the side of first importance. Comparatively few engineering apprentices rose to the eminence their technical skill merited, because they had not the requisite knowledge of how to manage men. The large and increasing number of industrial disputes was undoubtedly due to the want of tact in the management. If universities were to institute a course on the management of men it would be to the lasting benefit of the country. An engineer had no training in the power of speech, yet the power of the trained speaker was apparent everywhere.

The inability of clever technical men to write decent English has frequently been commented upon. It must be admitted, too, that the engineer, like the artist, is sometimes a poor business man. We suppose the reason is to be found in specialization. There is nothing in business which the engineer could not manage perfectly well, but he finds the theoretical and practical problems of engineering too absorbing to admit of time being appropriated for the minutiæ of commerce. Even the manufacturing side of engineering seems repugnant to some engineers. It is in the exploitation of patents, however, that we get the most striking illustration of the divergence between technical skill and business adroitness.

The conclusion is borne in upon us that in these days of specialization the engineer who interests himself to any extent on the business side must pass on much of the technical work to others. It seems to be well established that a successful engineering concern must have able specialists in both departments, and that this division of work must inevitably be more pronounced as the business expands.

In many small concerns both technical and commercial duties may be performed by the same person, but if the business grows a division on the usual lines is inevitable, and the head will have to ask himself whether his primary object in life is to revel in engineering details or to make money.

The Canadian Forestry Association, Commission of Conservation, Canadian Timbermen's Association, and the Canadian Society of Forest Engineers, all held annual meetings in Ottawa, January 17th, 18th and 19th.

Liquid chlorine has replaced hypochlorite of lime in the disinfection of water supply in Minneapolis. A contract has been let to Wallace & Tiernan, New York City, for the installation of three liquid-chlorine outfits with a capacity to treat 60,000,000 gallons a day each. The contract price was $2,000. The apparatus is of the solution feed manual control type, described in *The Canadian Engineer* for August 10th, 1915, page 276.

Editorial

ONTARIO'S PROGRESS IN HIGHWAY ORGANIZATION.

The Ontario Government has created a Department of Highways in connection with the existing Department of Public Works. Hon. Finlay McDiarmid has assumed the title of Minister of Public Works and Highways. Mr. W. A. McLean, C.E., M.Can.Soc.C.E., whose connection with road improvement in the province is prominent and of long standing, has been appointed Deputy Minister of Highways.

This is an appointment the announcement of which will be read with pleasure by engineers and road men in Canada and the United States, Mr. McLean being widely recognized as an eminent road authority. The Ontario Office of Public Roads has, under his direction, done a great deal to assist in the problems of rural transportation in Ontario. The work of the Public Roads and Highways Commission in 1913-14, presented in its 1914 report, evidenced the thoroughness with which the survey of Ontario conditions was entered into. The investigations and conclusions of the Commission were and are of great importance to the Province. The Highway Improvement Act of 1915, which went into force last week, and by which the Government pays 40 per cent. instead of 30 per cent. of the cost of construction of county roads by counties meeting the requirements of the department, and 20 per cent. of the cost of maintenance, has been a further step of great magnitude towards better highways in the province. The second instruction conference on highway work which will be held next month, being a series of lectures on road construction, given by the engineers of Mr. McLean's department for the benefit of county engineers and superintendents, marks the continuation of a most useful procedure, established last year.

These and other indications of the progressive steps towards cheaper transportation in the province are indicative of the extensive policy and indispensable organization which Mr. McLean has formulated. Undoubtedly his service to the province will be considerably increased by the added scope and powers which his new appointment as Deputy Minister confer upon him.

ZINC, COPPER AND NICKEL REFINING IN CANADA.

Very worthy of note among the industrial activities, the establishment of which in Canada is due in large measure to the necessities of the war, is the rapid advancement that is being made in the refining of metals. By virtue of the unusual demand for zinc, copper and nickel in the manufacture of munitions and armaments, at home and in allied and neutral countries, the progress made recently is most promising. Zinc, for instance, is now being refined electrolytically in Canada by three new plants, all using different processes. The Standard Silver Lead Mining Co., of Silverton, B.C., is producing electrolytic zinc by a process originated by French, using manganese in the electrolysis of zinc sulphate solutions, the manganese being recoverable, as it is deposited as manganese dioxide on the anode, and may be redissolved in sulphuric acid for future use. The Weedon Mining Co., with lead-zinc mines in Quebec, is using the Watts process in its refinery at Welland, Ont. By this method zinc is deposited from a zinc sulphate electrolyte, the quantity of sulphuric acid being kept down by the use of zinc oxide or some similar compound. At Trail, B.C., the Consolidated Mining and Smelting Company of Canada is using an older process, in use at Anaconda, Mont., and other plants, a process in which the electrolytic liquor containing sulphuric acid is used for bleaching the ore, just enough of the acid being used to form zinc sulphate for electrolysis, the idea being to keep the solution low in other constituents of the ore. At present the Trail plant is being greatly increased in capacity, to produce, it is stated, between 35 and 50 tons of metallic zinc per day. This indicates the success of the investigations carried on at the experimental plant there in 1915, the output averaging from 1,000 lbs. to 2,000 lbs. of spelter per day.

The zinc produced from the ores hitherto exported from British Columbia for want of a plant to treat them there has reached about 9,000,000 lbs. a year. Now the production of the province itself will aggregate from 25,000,000 to 30,000,000 lbs. It is interesting to know that development work done on the Sullivan mine by the company has proved it to be one of the largest and most valuable deposits of zinc ore on the continent. The company is driving a low-level tunnel two miles in length to provide for the economical mining and shipment of the ore from this mine, which will form the principal source of supply for the new zinc refinery at Trail.

Turning now to the enormous production of nickel in Ontario, last year's exports of which totalled nearly $7,000,000, and concerning which there was much controversy in the early stages of the war, it was recently announced in Ottawa that the nickel matte, in which form the metal has been exported for refining, may shortly, by Government requirement, be refined in Canada. This measure would mean the establishment of a very important industry in the Dominion, designed as it is to keep control of the export of a commodity that figures very prominently at present in armament manufacture.

MEASUREMENT OF RAINFALL.

The importance of knowing exactly the quantity of rainfall in hydrographic basins is evident. Besides the great scientific interest from the point of view of solution of numerous problems of terrestrial physics, there is the urgent and practical need associated with all hydrological subjects; utilization of water power, correction of streams, irrigation, agriculture, etc. In experiments described in Il Politecnico for June 30, 1915, a field rain gauge and a totallizer pluviometer were utilized, the latter indicating 9 per cent. less than the other. The most serious difficulty met with was to place the instruments in positions where they could not be tampered with. This difficulty was solved in a satisfactory way by putting them on the top of large masonry pillars. The mouths of the instruments measured 1 sq. dm., and the diameter of the cylindric part of the receptacle was 32 cm., the height 32 cm. Thus the capacity was about 28 litres, sufficient generally for a year's rain. The observations were made every month.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Elements of Mechanics of Materials. By C. E. Houghton, B.A., M.E., Associate Professor of Mechanical Engineering, New York University. Published by the D. Van Nostrand Co., New York. Second edition, 1915. 213 pages; 94 illustrations; cloth. Price, $2.00 net. (Reviewed by Eric P. Muntz, B.A.Sc., New Welland Ship Canal.)

For the purpose for which this book is intended—an elementary text book in conjunction with the usual engineering courses in colleges and universities—it covers the necessary ground in a clear-cut and concise manner, which should appeal to the average college student and to anyone endeavoring to master the elementary principles of design.

In the opening chapter the different stresses are explained, together with the meaning of unit deformation, coefficient of elasticity, elastic limit, resilience, etc., working stresses and factors of safety. This is followed by the application of these terms and stresses to bars of uniform strength, thin pipes, cylinders and thick pipes with a discussion of riveted joints and stresses due to temperature.

Chapter 3 deals with the "bar" of Chapters 1 and 2 in a horizontal position supporting loads perpendicular to its axis; *i.e.*, as a beam. The various bending moments and shearing forces are explained as well as section modulus, moment of inertia, etc., with their application to standard sections. Shear and moment diagrams and the effect of moving loads are explained.

Derivation of formulæ for tension is taken up in Chapter 4. Twist, relative strength and horse-power of shafts and shaft couplings are covered.

The equation to the elastic curve is derived, also formulæ for the deflection of beams, and the effect of restraining or fixing the ends of beams. Long columns are taken up with a review of Rankine's, Ritter's, the parabolic and straight-line formulas.

Combined stresses are covered in Chapter 7, and Chapter 8 takes up compound bars and beams, which is followed by the final chapter touching on reinforced concrete. Beams of rectangular and T-beam section are taken up. Their shearing and bond stresses are gone into. Web reinforcement necessitated by diagonal stress is also brought in, which revives the much-discussed question of the utility of *vertical* stirrups as web reinforcement. Their spacing, at all events, should be less than the distance from the centre of gravity of the steel to the neutral axis and not so great as ¾ d. as allowed in the book.

A very useful feature of the book is the large number of problems presented at the close of each chapter, occupying altogether fifty pages.

Altitudes in Canada. By Messrs. James White, Assistant to Chairman and Deputy Head, Commission of Conservation, Canada, and George H. Ferguson, Assistant Engineer. Published by the Commission. 603 pages, 8 maps and profiles, 6 x 9 ins., cloth.

The first edition of this work was published in 1901 when Mr. White was Chief Geographer, Department of the Interior. The present is the second edition, in which the information has been brought up to date and considerably enlarged upon. It is a very comprehensive compilation of altitudes and will be found exceedingly useful as the best possible interpretation of the conflicting evidence available respecting the elevation of many points in the Dominion. Its value as a work of reference in relation to climate, health, railway location, atmospheric pressures in machine design and construction, irrigation and pipe-line construction, etc., is self-evident in addition to the necessity of such information in geological and geographical problems.

Pocket Diary and Year Book, 1916. Published by Emmott & Company, Limited, Manchester and London. 428 pages, 4 x 6 ins., illustrated, cloth. Price 25 cents.

The 29th annual publication of the "Mechanical World" series, contains a collection of useful engineering notes, rules, tables and data. Many parts of the volume have been re-written and much additional information introduced.

Concrete Silos. By E. S. Hanson. Published by the Cement Era Publishing Co., Chicago. First edition, 1915. 174 pages, illustrated, 5 x 7 ins., cloth. Price, $1.00.

This is a very complete little treatise on concrete silo construction dealing first with the nature of the material, its suitability, and with instructions as to how to build according to the various systems in use. These systems of construction are many, and those which have been proven thoroughly reliable and practical are described in detail.

The book has eighteen chapters and a catalogue section. It is illustrated by numerous half-tones and line drawings.

Water Supply for Country Houses. By Dr. W. P. Gerhard, C.E. Published by Review of Reviews Company, 1914. 51 pages, illustrated, 6 x 9 ins., paper binding. Price, 40 cents.

The writer first deals with points to be borne in mind for the search for an adequate and suitable supply of water for domestic use. He treats of volume necessary, pressure required, etc., and deals with the various sources as rainfall, lakes, rivers, springs, etc. In Chapter 2 he refers to appliances for distributing water, power for machinery required, and lays out as an ideal system a compressed air pumping station.

First Course in Engineering Science. By P. J. Haler, B.Sc., and A. H. Stuart, B.Sc. Published by the University Tutorial Press, Limited, New Oxford Street, W. C., London, First edition, 1915. 191 pages, 159 illustrations, 5 x 7 ins., cloth. Price, 40 cents.

This book treats of the material laid down for certain technical school requirements in England. It describes experiments that may be performed on ordinary apparatus, the great difficulty in many institutions being the lack of suitable laboratory equipment for carrying out prescribed work.

The book has two parts, the first dealing with stresses, strains, moments, parallel forces, work, energy, power, velocity, acceleration, etc. The second deals with fluid pressures, heat, specific heat, conductivity, radiation, etc. It also treats in general way of the simple steam engine and boiler.

Examples in Magnetism. By Prof. F. E. Austin, B.S., E.E. Published by the author. First edition, 1915. 90 pages, 27 illustrations, 5 x 7 ins., flexible binding. Price, $1.10.

This book should be a favorable guide for students in elementary electrical engineering. As the author states, it is not a book of problems, but a carefully compiled volume of information dealing with physical laws underlying various problems, with the systematic tabulation of data relating thereto, with the process of solution and finally, in every case, with a problem properly worked out. The book does not enter into the analytical derivation of equations. These are taken for granted and the mathematical processes involved in their application to problems are dealt with.

Land and Marine Diesel Engines. By Giorgio Supino. Translated by A. G. Bremner and James Richardson. Published by Charles Griffin & Co., London. 309 pages, 380 illustrations, 19 plates, 6 x 9 ins., cloth. Price, $3.50 net.

This is an acceptable translation of the work of an Italian engineer of high repute. It deals with the development of the oil engine on the continent of Europe where the practice is considerably in advance of that of the United Kingdom and America. Part 1 involves six chapters relating to Diesel engines of both stationary and marine type; to fuels, thermodynamic cycles, efficiencies and the calculation of cylinder dimensions. Part 2 deals with engine design to which is devoted five chapters, and in addition there are supplementary chapters upon engine room accessories, fuel regulation, marine installations, tests, etc.

While calculations in the original work were based upon the metric system, the translators have added the British units where they tend to a readier understanding of the text. Calculations themselves are left in the metric system, and a convertion table is added.

The book has a very comprehensive index, list of illustrations, tables, etc.

Water Power Engineering. By Daniel W. Mead, Professor of hydraulic and sanitary engineering, University of Wisconsin, Consulting Engineer. Published by McGraw-Hill Book Co., New York. Second edition. 843 pages, 430 illustrations, 6 x 9¼, cloth. Price, $5.00 net. (Reviewed by T. H. Hogg, C.E., assistant hydraulic engineer, Hydro-Electric Power Commission of Ontario.)

The first edition of this treatise appeared in 1908, and in the past eight years has come to be recognized as a standard authority on hydraulic engineering, the advances in the art of which have been very great during this time. The new edition is therefore amply justified.

Chapter 1 gives a concise resumé of the history of water power engineering covering the improvement in design of water-wheels, both reaction and impulse, together with a short discussion on conservation and its effect on water power development.

Chapter 2 discusses the different losses in any plant, unavoidable and otherwise, and gives a list of units used in the analysis of conversion of energy.

Chapter 3, entitled "The Load," deals with load factor and the load curve and their significance as related to the efficiency and general design of waterpower plants. The chapters on "Rainfall," "Run-off" and "Stream Flow" of the first edition have been omitted, as not sufficiently complete.

Chapters 4 and 5 deal with the flow of streams and the measurement of stream flow. In these chapters are discussed the various formulæ for the losses in channels and conduits, and the various conditions influencing the flow of streams, together with a description of the standard methods of measurement of stream flow.

Chapters 6, 7 and 8 fall into a group dealing with the hydrograph in its relation to power plant design, the effects of pondage and storage, and the study of the power of a stream as affected by head. The author's use of the hydrograph is particularly to be commended. As he states, the graphical method is of great service in attacking many phases of the problem.

Chapters 9 to 13 deal with turbines, details and appurtenances, hydraulics of the turbine, testing and analysis and selection of turbines. This section, which is perhaps the most valuable of the treatise, has been re-written and a uniform nomenclature is used throughout. The treatment of turbine analyses is most concise and discusses the subject in the clearest possible way.

Chapters 14 to 18 take up speed regulation of turbine water-wheels, the governor, arrangement of reaction wheels, selection of machinery and design of plant; also examples of water power plants. The discussion of speed regulation is good. It is to be regretted, however, that more space is not given to the discussion of water, hammer, or pressure change. Joukowsky's analysis is given, but no mention is made of the more recent work of Allievi, and of Warren. Joukowsky's formula gives results which may be far from the truth when the time of the governor is taken into account.

The surge tank is treated in rather a perfunctory manner, the simple tank formulæ only being given, while inaccurate statements regarding the differential surge tank are made. A number of these tanks are in commercial operation, and the criticism that the sudden drop in the riser is opposed to good speed regulation is proved to be wrong. These tanks show remarkable results under operating conditions, and it is therefore unfortunate that the theory is not presented.

Chapters 19 to 21 deal with the relation of dam and power station, the principles of their construction and appendages of dams.

The cost of power plants and of power, the financial and commercial aspects of power development, and the analysis of water power projects are discussed in Chapters 22, 23 and 24. This section gives a much-needed warning against the financing of undesirable developments, and forms a valuable commentary on the economics of hydro-electric developments.

A criticism that may occur to the engineer after going over this book carefully is that perhaps too little attention has been given to recent modern developments using the single runner vertical type unit with scroll case and concrete draft tube, and to the various appurtenances such as trash racks and rock cleaning devices, flashboards, etc., and too much attention has been devoted to the old type multiple runner horizontal setting.

The treatment of the flow of water in pipes may appear to some to be inadequate. The economics of steel pipe line follows present-day practice, but leaves much to be desired. The method of balancing lost power through friction and cost to secure the most economical development might profitably be discussed with reference to such hydraulic elements as the canal or feeder pipe, the forebay and rocks and penstock.

While the value of the new edition might have been enhanced by the elimination of the defects above specified, it more than maintains the standing of the first edition as probably the most useful hydraulic treatise extant in the English language.

The Elasticity and Resistance of the Materials of Engineering. By Prof. Wm. H. Burr. Published by Messrs. John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. Seventh edition, revised, 1915. 927 pages, 173 text figures and 3 plates, size, 6 x 9 ins., cloth. Price, $5.50. (Reviewed by David A. Molitor, C.E., Designing Engineer, Toronto Harbor Commission.)

This work, which appeared in its first edition in 1883, is the most important and best known volume from the pen of Prof. Burr, for which reason no very lengthy review is considered necessary.

The book consists of two main parts and three appendices.

Part I., analytical, contains six chapters with the following chapter headings: 1, Elementary theory of elasticity in amorphous solid bodies; 2, Flexure; 3, Torsion; 4, Hollow cylinders and spheres; 5, Resilience; 6, Combined stress conditions.

Part II., technical, contains twelve additional chapters as follows: 7, Tension; 8, Compression; 9, Riveted joints and pin connections; 10, Long columns; 11, Shearing and Torsion; 12, Bending or Flexure; 13, Concrete steel members; 14, Rolled and cast-flanged beams; 15, Plate girders; 16, Miscellaneous subjects, curved beams, springs, flat plates, rollers, etc.; 17, The fatigue of metals; 18, The flow of solids.

Appendix I. treats of "Elements of Theory of Elasticity in Amorphous Solid Bodies" in three chapters, as follows: 1, General Equations; 2, Thick, Hollow Cylinders and Spheres, and Torsion; 3, Theory of Flexure.

Appendix II. devotes three pages to "Clavarino's Formula for Thick Cylinders."

Appendix III. gives four pages on "Resisting Capacity of Natural and Artificial Ice."

The present edition has received a very general revision with the aim of supplying new material to meet the advancing requirements of the profession. The empirical data has been materially enhanced, by the inclusion of results from more recent experimental investigations. The limitations set by a single volume preclude the possibility of exhausting this wide field of research which has received so much attention during the past decade.

The book might have been improved in its general arrangement by eliminating some of the approximate derivations which consume considerable space. These might have been given as approximations following the more exact demonstrations. Thus, arts. 24 to 33, covering 58 pages, deal with the theorem of three moments and beams involving redundancy, which problems can be more comprehensively solved by the use of the one general work equation which affords solutions to all redundancy problems with any degree of accuracy or approximation desired.

Other instances of this kind are noticeable, and space being a consideration in such a voluminous work, greater economy in this direction might have been practised without detriment to the book.

The author's treatment of reinforced concrete beams is commendable in this respect. The T-beam, being the more general case, is treated first, and the formulæ for plain rectangular beams are obtained by appropriate simplifications.

It is regrettable, however, that the high unit working stresses proposed in "the report of the Committee on Concrete and Reinforced Concrete" of the American Society of Testing Materials should find such a warm reception in the present treatise. If it is prudent to employ a factor of safety of about four for a material like steel, it is obviously unwise to allow a safety of only three for concrete on the basis of 28-day tests.

The calculus is freely employed, but this cannot be regarded as objectionable when dealing with intricate matters. The nomenclature is not generally uniform with American practice, so that a tabulated summary would have been a very useful addition.

On the whole, this volume contains much valuable information both for use as a text and reference book. In style, it corresponds to the uniform excellence of the Wiley publications.

Rivington's Notes on Building Construction. Edited by W. N. Twelvetrees, M.I.Mech.E. Published by Longmans, Green & Co., London. Part I., 306 pages; 484 illustrations. Part II., 332 pages; 395 illustrations; 6 x 9 ins.; cloth. Price, $2.25 each.

When to the title of this work we add the words "as practiced in England," and give a list of twenty-one names of contributing authors (including the names of some of the best-known architects and engineers in England), and mention at the same time that the present edition is the last revision of a book that has been a standard text for forty years, its character is well displayed.

It is intended as an authoritative text and hand book for students and architects, and certainly the comprehensive character of its subject matter, the concise yet clear treatment that prevails, and the prestige of the authors would indicate that its object is fulfilled.

Unfortunately, there exists so marked a difference in building methods and devices in England and on this continent that the Canadian reader will find the work of secondary value only. The architect or engineer fully conversant with American practice can use it with profit as a fertile source of suggestion, but not so the student if he hopes to put his reading into practice.

Unlike many books on building, Rivington's Notes does not indulge in pages of futile description in cases

where one clear drawing will suffice. In consequence, it is a very easy book of reference, and most valuable where working drawings can be used. Each term peculiar to any branch of building is usually defined at the first of the chapter dealing with that branch, and the text then proceeds with description and illustration of the best methods in vogue. Very little information is included concerning the properties of building materials, and some of what is given is not true of the materials on this market. Where so many writers have had a finger in the pie one would expect to find repetition and contradiction, and that this is so in a very minor degree speaks well for the book and its editor. On the whole, it is a very excellent work, containing such a fund of building fact that it can not fail to be of value to any one occupied with building.

PUBLICATIONS RECEIVED.

American Society for Testing Materials.—Proceedings of 18th annual meeting.

Upper White District, Yukon.—By D. D. Cairnes. Report to the Department of Mines, Canada.

Department of Naval Service.—Report of the Deputy Minister for fiscal year ending March 31st, 1915.

Arisaig-Antigonish District, Nova Scotia.—By M. Y. Williams. Report to the Department of Mines, Canada.

Department of Public Works, Canada.—Report of the Minister for the fiscal year ending March 31st, 1915.

U.S. Bureau of Mines.—Fifth annual report of the director to the Secretary of the Interior of the United States.

The Oil and Gas Fields of Ontario and Quebec.—By Wyatt Malcolm. Report to the Department of Mines, Canada.

Department of Marine and Fisheries of Canada.—Forty-eighth annual report, covering the fiscal year 1914-15.

Canadian Production of Coal and Coke.—Annual report for the year 1914, as prepared by Mines Branch, Department of Mines, Canada.

Canada and the British West Indies.—By Watson Griffin. Published by authority of Sir George E. Foster, Minister of Trade and Commerce.

Relining Old Brick and Ashlar Sewers.—Bulletin on use of the cement-gun in this work. Published by the Cement-Gun Co., Inc., New York City.

Trenching Machinery.—U.S. Department of Agriculture, Bulletin No. 98, concerning trenching machinery used for the construction of trenches for tile drains.

Asphalt Primer and Colloidal Catechism.—A 20-page publication of the Barber Asphalt Paving Company, Philadelphia, explaining the principles of colloidal chemistry as applied to the paving industry.

Duty of Water Experiments.—Bulletin No. 4 of the Irrigation Branch, Department of the Interior, Canada, relating to experiments conducted at various points in the Canadian West. 62 pages, 6 x 9 inches, illustrated.

British Columbia Hydrographic Survey.—Water Resources Paper No. 14, Water Power Branch, Department of the Interior, Canada. Report for 1914, prepared by R. G. Swan, Chief Engineer; 534 pages, illustrated.

CATALOGUES RECEIVED.

Wells Light for Contractors, Etc.—Catalogue regarding portable night light burning kerosene oil. Published by the Alexander Milburn Co., Baltimore, Md.

COAST TO COAST

Calgary, Alta.—The Ogden bridge has reached such a stage of construction that street railway traffic is now passing over it.

Mimico, Ont.—The construction of the joint sewerage system of New Toronto and Mimico is proceeding with few interruptions owing to severe weather.

Winnipeg, Man.—The Arlington Street bridge has been practically completed and arrangements are being made for the routing of street car traffic over it.

Hamilton, Ont.—H. M. Marsh, Industrial Commissioner, in his annual report, stated that during the past year eight new industries had located in Hamilton.

Edmonton, Alta.—The total mileage of water mains in Edmonton at the present time is 162.23, with the number of services 10,495, or an average of 64.6 to the mile.

Munro Township, Ont.—An important platinum find is reported in Munro Township, ten miles east of Matheson, Northern Ontario. It is stated that assays, of which five were made, run from $180 to $1,800 a ton.

Montreal, Que.—An announcement has been made that the Canadian Car and Foundry Company has obtained a loan of $1,500,000 from the Russian government, and it is understood that more funds will be available from the same source as needed.

Winnipeg, Man.—The Greater Winnipeg Water District Commission states that there will be no delay, owing to the financial condition, in the completion of the Shoal Lake aqueduct. Arrangements have all been made regarding money matters.

North Vancouver, B.C.—According to the annual report of Mr. A. B. Clucas, acting city engineer, during 1914 there were constructed in the municipality 1.5 miles of sidewalk, 1.7 miles of road graded, 3.9 miles of roads cleared, .17 mile of water mains laid, three hydrants and 28 gate valves installed.

Vancouver, B.C.—A decision favoring McIllwee and Sons in their suit for a quarter million dollars damages against Foley, Welch and Stewart over boring the C.P.R. tunnel at Roger's Pass has been handed down by the Privy Council, which dismissed with costs the appeal of Foley, Welch and Stewart from a judgment of the British Columbia Court of Appeals, awarding McIllwee and Sons the full amount of their claim. The plaintiffs claimed damages for a cancelled contract.

Toronto, Ont.—It is reported that legislation will be introduced at the coming session of the Legislature to provide for about $300,000 more for the Toronto-Hamilton highway. This road will cost when completed about $850,000 or $900,000, whereas the money provided under the original estimate by debentures was only $600,000. The increase in cost has been partly occasioned by the decision of the commission to increase the width of the road from 16 feet to 18 feet. This caused an additional cost of one-eighth, or $75,000. Other items in increasing the cost were: The extra cost of carrying on operations in the cold weather; the effort to supply employment, $50,000; old concrete culverts which were undermined and had to be replaced, $100,000; washouts occasioned by a great midsummer rainstorm, $50,000.

PERSONAL.

C. D. CAMPBELL, city engineer of Galt, Ontario, has resigned.

J. S. LAING, B.A.Sc., formerly assistant engineer of Galt, Ont., has been appointed town engineer of Barrie, Ont.

H. L. VERCOE has been appointed special engineer of the Canadian Northern Railway for lines west of Port Arthur, Ont.

J. C. BRECKON, formerly waterworks engineer for the city of Vancouver, B.C., is now associated with the engineering firm of Du Cane, Dutcher & Co., Vancouver.

N. W. EMMENS has severed his connection with the Great Western Mines Development Co., Limited, and has opened an office in the Credit Foncier building, Vancouver, B.C., as consulting mining engineer.

Captain PAUL F. SISE, B.Sc., has been appointed adjutant of the 148th Battalion, Montreal, and has volunteered for overseas service. Captain Sise is vice-president and general manager of the Northern Electric Company. He was born November 10th, 1879, and was educated at Bishops College School, Lennoxville, Que., and at McGill University. He was one of the organizers of of the University Club, Montreal.

Capt. Paul F. Sise.

Lieut. W. H. MUNRO, manager of the Peterborough Radial Railway, has been promoted to a captaincy. He is in the mechanical transport branch of the Canadian Army Service Corps and went to England last July.

MANFRED FREEMAN, who has been elected public utilities commissioner for Lethbridge, Alta., to succeed Mr. Reid, has been connected with the Lethbridge Waterworks and Electric Light Company as chief engineer, manager and secretary.

W. N. JOHNSTON, B.Sc., has received the appointment of costs engineer on a new piece of construction for the Canadian Copper Co. at Copper Cliff, Ont. For the past two years Mr. Johnston has filled the position of resident engineer on sewer construction for the city of Toronto.

W. A. McLEAN, C.E., M.Can.Soc.C.E., has been appointed Deputy Minister of Highways for the Province of Ontario. The appointment is the result of the establishment of a new Department of Highways by the Government. Mr. McLean has been connected with the Department of Public Works since 1896, prior to which he was for three years engaged in municipal engineering at St. Thomas, Ont. His appointment to the position of Provincial Engineer of Highways, several years ago, was a very popular and well earned promotion. He has since acted as secretary of the Ontario Public Roads and Highways Commission. Last year he was president of the Canadian International Good Roads Convention, and in 1914 acted in a similar capacity for the American Road Builders' Association. He is a member of the Canadian Society of Civil Engineers, and is chairman of its standing committee on roads and pavements. He is a member also of the Association of Ontario Land Surveyors.

OBITUARY.

The death has been announced of Mr. Griffith D. Walters, who died in Calgary, Alberta, January 14, 1916, after a brief illness following an operation for appendicitis. Mr. Walters was born in Wales in 1884. He received the degree of B.S. in civil and irrigation engineering in the Colorado Agricultural College in 1911 and during the following year was assistant in irrigation investigations there under V. M. Cone. In 1913 he was engaged to take charge of the duty of water investigations for the Canadian Government under F. H. Peters, M.Am.Soc.C.E., M.Can.Soc.C.E., Commissioner of Irrigation, and was at the time of his death chief agricultural engineer, Irrigation Branch, Department of the Interior.

OTTAWA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

On January 21st, Mr. G. R. G. Conway, M.Can.Soc.C.E., consulting engineer, Toronto, addressed the members of the Ottawa Branch of the Canadian Society of Civil Engineers. Mr. Conway chose as his subject "The Engineer and Standards of Beauty," in which he urged a freer co-operation between engineers and architects in the design of engineering structures, particularly in great public works such as bridges, railway terminals, dams, aqueducts, power houses, public highways, etc. The paper was fully illustrated with lantern slides giving examples of engineering structures where this co-operation had been attempted, and in some cases successfully carried out.

The branch has recently made arrangements with the officers of No. 3 Field Company, Canadian Engineers, for members of the branch to attend the lectures and drills. Three classes of participation in the military work have been arranged for: (1) drill and lectures with a view to taking examination for officer's certificate; (2) drill and lectures, but no examinations; (3) lectures only. Members in classes 1 and 2 will be attached as civilians to No. 3 Company.

The first lecture, January 28th, will relate to the "Royal Engineer and Signal Unit with an Army in the Field." Lectures will follow weekly.

Examinations will be held in April on the following subjects: Infantry training, military engineering, interior economy, organization and equipment, military map reading and sketching.

A special committee on military engineering has been appointed by the managing committee of the branch, consisting of the following: W. S. Lawson, chairman; R. de B. Corriveau, G. G. Gale, Alex. Gray, J. B. Challies.

COMING MEETINGS.

CANADIAN RAILWAY CLUB.—Fourteenth annual dinner to be held at 8 p.m. January 29th, 1916, in the Green Room of the Windsor Hotel, Montreal. Tickets may be obtained from Jas. Powell, secretary, P.O. Box 7, St. Lambert, P.Q.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—To be held in Chicago, Ill., February 4th, 1916. Joint dinner that evening with American Electric Railway Manufacturers' Association.

NINTH CHICAGO CEMENT SHOW.—At Chicago, Ill., February 12th to 19th. R. F. Hall secretary, 208 South La Salle Street, Chicago, Ill.

Volume 30. Toronto, February 3, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

CANADIAN SOCIETY OF CIVIL ENGINEERS

THIRTIETH ANNUAL MEETING AT MONTREAL LAST WEEK GENERALLY DEEMED TO BE THE MOST INTERESTING AND INSTRUCTIVE THAT THE SOCIETY HAS HELD FOR SEVERAL YEARS—IMPORTANT MATTERS DEBATED.

RECOMMENDATIONS for a change in the name of the Society, an appointment of a committee to revise the by-laws, the defeat of the Western amendments to by-laws, and means of meeting financial difficulties, were the chief items of discussion at the thirtieth annual meeting of the Canadian Society of Civil Engineers, held last week at Montreal.

The meeting was called to order at 10.35 a.m., January 25th, with President F. C. Gamble, of Victoria, B.C., in the chair. Prof. C. H. McLeod, secretary of the Society, read the minutes of the last annual meeting.

The first business brought before the members was a resolution expressing great appreciation of the knighting of Sir John Kennedy, Sir Collingwood Schreiber and Sir Alexander Bertram. It was felt that His Majesty had honored not only those three members of the Society, but also, through them, the entire engineering profession in Canada. Sir John Kennedy was present and rousing cheers were given for him, to which he very modestly replied that the honor accorded to him was not at all personal, but was meant for every engineer in Canada.

A telegram of thanks for the contributions to the Engineers' Hospital Fund, signed by General Charles J. Armstrong, chief engineer of the Canadian Army Corps, was read by the secretary. The meeting framed a reply, wishing a speedy and victorious return of all Canadian engineers now at the front. This reply was cabled to General Armstrong.

The president appointed the auditors of the Society, Messrs. Riddell, Stead, Graham and Hutchison, as scrutineers to examine the ballots for officers and for amendments to by-laws. In previous years members of the Society had been appointed scrutineers, and G. A. Mountain questioned the legality of the departure from precedent. An examination of the by-laws showed that the appointment was quite in order.

William McNab wanted to know why the Dominion Government has not accepted the Society's steel bridge specification as standard. The discussion that followed showed that the chief engineer of the Department of Railways and Canals now has the matter under consideration.

The report of the council of the Society was received and adopted, as was also the report of the library and house committee.

The treasurer's report brought on a discussion of the finances of the Society which occupied the remainder of the session. The finance committee made a special report, showing that the income of the Society for 1916 would be considerably less than for 1915 unless many new members should join the Society, and that rigid economy in all matters would have to be the rule. This report, showing exhaustive study of the subject by the finance committee, was appreciated by the members, and they decided to co-operate with the council in every possible way in reducing expenditures consistent with proper service to the membership. For one thing, it was decided to forego printing the list of members this year, and to issue instead a booklet giving the changes in address, additions to membership, etc.

Walter J. Francis, chairman of the papers committee, gave out the following statement, showing that the Society is spending less per member on printing than is any of the other leading engineering societies on this continent, and also that the cost of its printing per page of Transactions is far below that obtained by the other societies:—

TABLE I.—COMPARATIVE STATEMENT OF PRINTING EXPENDITURES.

Name of Society	No. of Members	Printing				Postage	
		Cost of Printing	Expense per Member	No. of Pages of Transactions	Cost per page of Transactions	Total Cost	Expense per Member
American Society of Civil Engineers	7,900	$54,676	$6.90	(3,120a) (1,956b)	$21.50	$ 7,338	$0.92
American Society of Mining Engineers	5,000	38,203	7.64	1,569	31.40	—	—
American Institute of Electrical Engineers	7,700	48,103	6.25	2,191	21.95	6,427	0.85
American Society of Mechanical Engineers	7,000	56,938	8.47	1,135	50.15	10,200	1.44
Canadian Society of Civil Engineers	3,060	5,970	1.95	659	9.05	1,887	.62

(a) 1914. (b) 1915

Mr. Francis stated that the above table shows conclusively that the members of the Canadian Society of Civil Engineers are faring very well in proportion to the funds available for printing. He said that it also showed the desirability of making the new printing contract about eighteen months ago whereby the printing was taken out of the hands of Montreal [illegible] and

entrusted to *The Canadian Engineer* upon a basis most favorable to the Society. The comparisons in Table I. are summarized more clearly in Table II.

TABLE II.

	No. of Members	Cost of Printing	Expense per Member	No. of Pages of Transactions	Cost per Page of Transactions	Cost of Postage	Postage Expense per Member
Canadian Society Civil Engineers	3,060	$ 5,970	$1.95	659	$ 9.05	$1,887	$0.62
*Other Societies..	6,900	49,480	7.32	1,858	31.25	7,988	1.07

*Average of the four American Societies named in Table I.

Mr. Francis, together with R. A. Ross, chairman of the finance committee, further pointed out that all other disbursements of the Society were equally low. The secretary of the Canadian Society, they pointed out for example, receives a salary less than one-sixth as great as that paid to the secretary of the kindred American Society. Table III. is a statement giving some interesting comparisons along these lines.

TABLE III.—COMPARATIVE STATEMENT OF ALL EXPENDITURES.

Name of Society	No. of Members	Clerical Staff		Disbursements		Income	
		Total Cost	Expense per Member	Total	Per Member	Total	Per Member
American Society of Civil Engineers ..	7,900	$39,311	$5.00	$169,670	$22.00	$160,195	$20.80
American Society of Mining Engrs....	5,000	19,308	3.86	120,969	24.20	115,582	23.12
American Institute of Electrical Engrs.	7,700	28,588	3.60	105,874	13.54	112,775	14.06
American Society of Mechanical Engrs.	7,000	*18,269 †45,000	2.60 6.43	118,847	18.24	147,629	21.09
Canadian Society of Civil Engineers ..	3,060	3,768	1.23	19,775	6.46	22,079	7.20

* Printed Statement. † Actual as compiled by Secretary.

The data given in Table III. is even more clearly shown in the summarized form in which it is presented in Table IV.

TABLE IV.

	Cost of Clerical Staff		All Disbursements		All Income	
	Total	Per Member	Total	Per Member	Total	Per Member
Canadian Society Civil Engineers	$ 3,768	$1.23	$19,775	$6.46	$22,079	$7.20
*Other Societies........	29,710	4.24	128,840	19.44	144,045	19.76

*Average of the four American Societies named in Table III.

Mr. Francis said that it had been suggested to him that the American Society of Civil Engineers did not spend as much money when it had 3,000 members as the Canadian Society does now with 3,000 members. He showed annual reports of the American Society for the two years during which its membership approximated 3,000, and they showed that even then the expenditures per member for every item were greatly in excess of the Canadian Society's present expenditures, running from two and a half to four times as great. The income per member was also much larger. It was deemed undesirable, however, to raise the dues of the members of the Canadian Society.

Discussion following upon the presentation of these reports showed that the members were much pleased by the data given, and every expression of confidence was voiced as regards the finance committee and their ability to steer the Society safely through the present strenuous times. The meeting then adjourned till 3 p.m.

E. W. Oliver opened the afternoon session with a discussion on the amendments to by-laws, and the ensuing debate lasted until 5.20 p.m. The best speech of the debate was made by Sir John Kennedy, who said that the main intention of the Society was educational. The Society cannot be a trade union, cannot secure positions for its members, nor hold them in positions. In many other ways the activities of the Society cannot be exerted with dignity. The revision of by-laws is a perennial subject in all societies, and so is the question of smaller units within societies. Engineers are specializing to-day, and each specialty has its own subjects to discuss, and this has at times led to the formation of separate specialized societies in which to discuss them. Such units are more practical than the dividing of a national organization into provincial or district organizations.

But in Canada, thought Sir John, it is better to have one broad national society at present, divided neither by geographical lines nor by specialties, although a certain amount of splitting up of the activities within the Society is inevitable and desirable. The machinery for this exists to-day in the various sections within the Society. At the Montreal meetings, the electrical section has a paper one time on electrical subjects, the mining section another time on mining subjects, etc. This has really kept the Society together, by enabling each to follow out its specialty, yet all meetings have been attended by all members in general, with the result that it has broadened all of our views. It has resulted in a certain amount of overlapping, but even that is good, as it is desirable to interchange ideas. The railroad man, for example, should have some idea of the problems encountered by the waterworks engineer, and vice versâ.

The Society is a centre of information, and while none can expect to be advanced individually by it without his own efforts and worth, yet all can derive much benefit from it. Sir John said he had in his lifetime received a carload of books from the various societies to which he belongs, and that he had obtained a wonderful lot of information of value from them.

He said that he hoped the provincial idea will not grow too strong. The Society's efforts should not be localized too much. For instance, while proud of membership in a national institution like the I.C.E. of Great Britain, he would not care about belonging to a localized society of Irish engineers, or Welsh engineers.

As a result of the discussion, three members submitted conflicting motions regarding the formation of a committee to revise the by-laws, and the president appointed Messrs. Oliver, Conway and Jamieson as a committee to get together and agree upon a motion

which would be satisfactory to all for presentation the following day.

As the hour was late, the reports of branches were received but not read nor discussed. Abstracts from these reports appear on page 204 of this issue of *The Canadian Engineer.*

The report of the Portland cement specifications committee was received, and the specifications they recommended were adopted as the official specifications of the Society, and were ordered to be printed and distributed to members. The report of this committee appeared on page 158 of the January 20th issue of *The Canadian Engineer.*

The meeting then adjourned till 3 p.m. of the following day, Wednesday, January 26th, as Wednesday morning was to be devoted to an inspection trip.

Tuesday evening a smoker was enjoyed at the Society's building, 176 Mansfield Street, where all the business sessions also were held. Several professional entertainers amused the members, and a very pleasant evening was passed. The following morning special cars conveyed the members to the plant of the Canadian Vickers, Limited, where all departments were inspected with great interest.

At the Wednesday afternoon business session E. W. Oliver introduced the joint motion previously mentioned, calling upon council to appoint a committee to decide upon a policy for increasing the prestige of the Society, and for studying the organization and by-laws, and to advise concerning any necessary changes in same; the committee to report to council by September 1st, 1916, and their report to be printed and distributed to all members within thirty days. This was carried with an amendment to the effect that the members of the committee should not be appointed by council, but should be directly elected by the membership, each district electing its own representative. One member is to be elected from each district excepting No. 1, which is to have two members. The branches are to nominate the members, and a ballot is then to be sent out to the members in each district for the election of one of those so nominated.

A letter from J. G. Legrand, of Winnipeg, was read, urging all to do their duty to the Flag at this time.

In a discussion of the above motion, Walter J. Francis thought that insinuations were made that interest in the Society is decreasing. He said that he remembered the time when it had been difficult to get a chairman at the meetings in Montreal. Now there were five or six councillors at every meeting, all willing to preside. He remembered times when only 15 or 20 McGill students and a handful of "old war horses" were the only ones who attended the meetings. Now the assembly room was crowded at meetings, and at times every possible thing that could be sat upon was utilized. Formerly it was often impossible to obtain a quorum at council meetings. During the past year the average attendance at council meetings was much more than a quorum, and some councillors had missed only a few meetings during the whole year. Phelps Johnson had missed scarcely one for years. Did that show decreasing interest in Society affairs?

Mr. Francis had just warmed up to his subject and was "going strong" when members interrupted him and assured him that he had misunderstood certain remarks, and that nobody intimated any lack of interest on the part of the council or the members, so Mr. Francis accepted that statement and did not finish his remarks.

The report of the Committee on Conservation was read by James White. This report was summarized on page 158 of the January 20th issue of *The Canadian Engineer.* Mr. White stated that the figure of $45,000,000 for fire losses per annum in Canada was a clerical error made in his office, and that it should have been $35,000,000, consisting of $10,000,000 forest fires and $25,000,000 other fires.

Conservation means national efficiency, said Mr. White, and perhaps the Commission of Conservation should have been called the Commission of National Efficiency. Mr. White stated that there were 197 delegates from all parts of Canada at the Civic League meeting at Ottawa on January 20th. He stated that within the next month a report on the water-powers of British Columbia would be printed by the Conservation Commission, and he added the following paragraphs to the committee report as originally presented:—

"Substantial progress has been made by the various organizations of the Dominion and Provincial Governments in investigating the water resources of the Dominion. The only province that is not now provided with some form of water resources investigation is New Brunswick, but negotiations, now under way, will probably lead to some satisfactory arrangement in the near future. Manitoba, Saskatchewan, Alberta and British Columbia have permanent systematic hydrographic organizations under the direction of the Minister of the Interior. Ontario is gradually being covered by the hydraulic division of the Ontario Hydro-Electric Power Commission. Quebec is being looked after by the Quebec Streams Commission and the chief engineer of Hydraulic Forces. In Nova Scotia there is a co-operative agreement between the Dominion Water Power Branch of the Department of the Interior and the Nova Scotia Water Power Commission.

The field investigations of these organizations are being published in a very satisfactory form, although there has been some delay in publishing the data promptly, following the completion of the calendar or water year, as the case may be. The chief engineers of the above organizations have had several informal conferences with a view to co-ordinating, systematizing and standardizing their work, and also to facilitate the publication of the data in a uniform way and promptly. The net result of these informal discussions will be that, in the near future, Canada will be completely covered by efficient and effective organizations charged with the responsibility for investigating, in the most complete and comprehensive manner consistent with the dictates of economy, the water resources of the Dominion."

At this juncture Prof. Haultain took objection to Mr. White's report and strongly opposed its adoption by the Society. Prof. Haultain contended that it is still very doubtful whether phosphates have been found in commercial quantities in Rocky Mountains Park; he wanted further information regarding the appointment of a chief inspector of mines, and made certain charges in connection with same; he wished to know what part the Society was asked to take in the affairs of the Civic Improvement League, and why their work should be endorsed; he objected to references to individuals as "the greatest experts in the world," etc.

Mr. White replied in very caustic manner, defending all the statements made in his report. Nevertheless, the meeting decided to receive the report but not to "adopt" it, and this was subsequently made the uniform practice in regard to all committee reports.

The Electro-Technical Committee's report was received and the committee continued.

The Committee on Steel Bridge Specifications made no definite report, but asked to be continued. P. B. Motley, the chairman, wished to have the committee made up of Montreal men only, to facilitate getting them together for discussions, but this was over-ruled. In this connection attention was called to the commendable inauguration during the past year of sub-committees of the Toronto branch, to report to the main committees of the Society and to assist them. The idea of such branch committees was approved of as being likely to give valuable ideas to the main committees.

G. A. Mountain called attention to the advisability of retaining representation of all interests on this committee, so that ultimately its specifications would be adopted by all, resulting in one standard set of steel bridge specifications for the entire Dominion.

The president, F. C. Gamble, then read his address, a brief abstract of which is given on page 205 of this issue. He prefaced his paper with the following remarks:—

"The past year has been one of stress and anxiety. The British Empire has been engaged for eighteen months in the greatest struggle in the history of the world with a nation which for over forty years has been unsparing in preparation for imposing upon the world by force its system of civilization and "Kultur." Notwithstanding the serious handicap of unpreparedness under which the Empire entered upon this war, the British Army, under the unsurpassed guardianship of the Grand Fleet, and supported by contingents from the Overseas Dominions, has withstood the violent attacks of the enemy in Flanders and France with courage and valor.

"It is not too optimistic to say that the ultimate end shall be the triumph of British principles of liberty and justice. To assist loyally in the task thus imposed upon the Empire about three hundred and sixty-three members of our Society (twelve per cent. of the total membership) have given their services freely, of which number thirteen have so far made the supreme sacrifice. We honor those who have died that the Empire may live, and extend to their relatives an expression of our admiration and deepest sympathy. While the memory of their deeds will remain in our hearts as long as we live, it is but fit and proper to commemorate by a tangible token their noble patriotism and unselfish surrender of their lives.

"In one way the Society has already marked its appreciation of this by remitting the annual dues of members actively engaged at the front. This should meet with the unanimous approval of members.

"In the report for the year 1915 the membership of all grades was 3,058. At the commencement of this year (January, 1916), taking into account deaths, resignations and removal from roll for non-payment of dues, the membership is about the same.

"We have to mourn the loss by death during the past year of sixteen members, including juniors and students. Of these, thirteen were killed in action, to which a previous reference has been made. Of the others, special mention should be made of the late Mr. T. C. Keefer, C.M.G., first and tenth president of the Society, and afterwards honorary member, and of Sir Sandford Fleming, who became a member in 1896, and was made an honorary member in 1908. These gentlemen conferred a marked distinction upon the Society, having acquired by probity, eminent ability and usefulness, world-wide reputations. Their careers must be an inspiration to the younger generation.

"There are many Civil Engineers living in the Dominion of marked ability who still hold aloof from us. These can only be induced to join by raising the Society to its proper plane of usefulness and increasing its sphere of influence. Solicitation to join us must be avoided as an undignified and weak expedient. It is quality, not quantity, that is desirable. A most essential factor in bringing about the increase in our membership, attracting to us the most accomplished Civil Engineers, is the firm and courageous carrying out of "The Code of Ethics" adopted by the Society.

"The profession of Civil Engineering, owing to its somewhat uncertain position, having no legal standing, differs from other professions which enjoy the law's protection, and, therefore, there is the more necessity for members to practise the virtue of loyalty to each other and to the profession. If each member realizes his responsibility in this respect public esteem and confidence will increase.

"The Council during the past year has been active in bringing to the attention of governing bodies—Federal, Provincial and Municipal—matters of importance and intense interest to the profession of Civil Engineers practising within the bounds of the Empire. Although no direct beneficial results have been achieved so far, we have no reason to be discouraged. In the coming year, if the past representations are firmly and fearlessly persisted in, some measure of success will without doubt attend our efforts. We are not demanding anything unreasonable or beyond our rights as citizens. We should resent firmly any adverse inference to be drawn from the continued indifferent treatment meted out to the profession by public bodies in Canada. The amelioration of the disabilities under which we labor at present is one of our just demands.

"The Society, through the Council, might well direct its energies towards securing the adoption by governments, for Civil Engineers in the public service, of a standard of qualifications not short of that required by the Society for Associate Members. The Institution of Civil Engineers took this question up with the Imperial Government, meeting with a sympathetic response, and this Society should not hesitate to move in the same direction. It is unfortunately a fact that many positions requiring proper engineering qualifications have been filled by men who have never had either engineering education or experience.

"It would be well also to follow the example of the Institution in another direction. A Civil Engineers Appointment Board, while in no sense to be part of or associated officially with the Society, might be established with the full sympathy of the Council. The Board established in London on these lines has proved useful to engineering employees and younger members of the profession.

"The speaker is of the opinion that this Society, through the Council, should make strong recommendations to the Government of Canada with regard to such of our members who are eminently fitted by age, attainments and experience for commissions in the Corps of Canadian Engineers. There are many whose professional knowledge is more or less wasted in infantry battalions as officers and privates at the present time. In England the Imperial Government has consulted with the Institution of Civil Engineers with regard to members

eligible for commissions in the Royal Engineers, and the recommendations of the Institution have been successful. Why should not this Society and the Government of Canada work together in the same most desirable manner?"

After hearing the president's address the meeting adjourned until 10 a.m., Thursday, January 27th.

In the evening a dinner was given at the Engineers' Club, the visiting members being the guests of the Montreal members. Informal speeches reflected the brotherly feeling underlying the relations between all members regardless of occasional differences of opinion.

On Thursday morning the members received and adopted the following report from the scrutineers:—

AMENDMENTS TO BY-LAWS PROPOSED BY COUNCIL.

	Aye.	Nay.	Not voting
By-law 7	395	52	15
" " 18	386	57	19
" " 27	321	116	25
" " 29	386	44	32
" " 30	334	98	30
" " 36	361	60	41
" " 50	125	17	320
" " 56	326	87	49

AMENDMENTS TO BY-LAWS PROPOSED BY TEN BRITISH COLUMBIA MEMBERS.

	Aye.	Nay.	Not voting.
By-law 7	42	371	49
" " 8	117	229	116
" " 9	119	242	101
" " 10	119	242	101
" " 16	145	218	99
" " 27	97	298	67
" " 30	101	301	60
" " 33	101	264	97
" " 56	96	285	81

There were 462 ballots cast altogether. From the above it will be seen that all of the Western amendments were decisively defeated and all of the Council's amendments were carried excepting that to By-law 50, which result was due to the line "Aye and Nay" under that amendment being accidentally left off the printed ballot.

The election for officers resulted as follows: Vice-president, Thos. H. White, Vancouver. Councillors—Walter J. Francis, Montreal; H. K. Safford, Montreal; H. Donkin, Halifax; A. E. Doucet, Quebec; E. D. Lafleur, Ottawa; J. R. W. Ambrose, Toronto; D. A. Ross, Winnipeg; D. O. Lewis, Vancouver. George Herrick Duggan, Montreal, was elected as president by acclamation.

After the scrutineers' report the newly-elected president took the chair amid applause, and expressed his appreciation of the honor bestowed upon him.

Election of Nominating Committee for 1916 was then held, resulting as follows: E. Brown, G. G. Murdoch, A. Tremblay, G. A. Mountain, A. F. Macallum, J. Chalmers, E. A. Cleveland.

Continuing the reception of committee reports, Andrew F. Macallum was asked to present the report of the Roads and Pavements Committee, abstracts of which were given on page 159 of the January 20th issue of *The Canadian Engineer* and on page 185 of last week's issue.

G. A. McCarthy, chairman of the Toronto branch, called the attention of the members to the honor that had been accorded to a member of the Toronto branch in the election of Mr. Macallum to the presidency of the American Society of Municipal Improvements for the year 1916. The meeting recorded its gratification at this honor paid to one of the Society's members.

F. H. Pitcher, chairman of the Committee on Cast-iron Water Pipe, reported that there is nothing new of sufficient importance to warrant any change in the cast-iron pipe specifications in view of the best practice in the manufacture and use of cast-iron pipe. The meeting authorized the printing of a new edition of the present specifications.

Walter J. Francis, chairman of the Committee on Concrete and Reinforced Concrete, reported that voluminous discussion of the standard specifications for concrete and reinforced concrete had been received from the special committee of the Toronto branch and had been placed in the hands of the members of the main committee.

Henry Holgate, chairman of the Committee on General Clauses for Specifications, reported as follows:—

"Last year's report on general clauses for specifications was referred back to the committee, and the committee was increased in numbers. In the light of subsequent study, the report submitted at the last annual meeting is deemed quite inadequate, and the committee has not yet reached conclusions which can be recommended to the Society for adoption.

"It is doubtful if any set of general clauses can be compiled which can be used as intended under the instructions given to the committee, as the varying demands of contracts for work are so many and the conditions under which they are to be carried out are so various.

"Specifications and contracts for one stated class of work might, perhaps, have standard clauses of conditions, but these might not be applicable to a similar purpose on contracts for work of another variety, and if used, might in all probability lead to disastrous confusion.

"The committee has come to the conclusion that it is not desirable to advise the adoption of one set form of general clauses for specifications, and that if any useful purpose is to be served by standard general clauses, the various classes of work so affected must be separated, and clauses applicable to each class drawn separately, so as to suit the particular class of work.

"Much useful discussion has taken place in the course of the committee's work, which will form the base for further study, but the committee feels it inadvisable to make a report under the existing instructions of the Society, and will await its further instructions." The committee was asked to continue its work.

Prof. H. M. Mackay, chairman of the Board of Examiners, reported that nine examinations were held during the year. Five passed, four failed. The number of examinations is smaller than usual, owing to the recent amendment to By-law 8, which permits of the examination for Associate member to be waived in case of candidates who have had five years' responsible charge of work.

A resolution calling attention to the practice of engineers who are called upon to pass on waterworks and sewerage plans submitted to Provincial Boards of Health being financially interested in special forms of treatment, was submitted to the meeting by Prof. W. Muir Edwards, of Edmonton. After discussion it was decided that this was so fundamental and obvious a feature of business and engineers' ethics that it would be superfluous to call the attention of the Provincial Boards of Health to the matter.

G. R. G. Conway, Toronto, presented the following resolution, seconded by G. A. Mountain:—

"That the Canadian Society of Civil Engineers, assembled at their annual meeting, and including representatives from all parts of Canada, realizing that the work of the trained engineer is becoming more and more of vital importance for the successful termination of the present war, desires to place at the disposal of the Dominion Government its organization for the purpose of assisting and co-operating, by every means in its power, in properly training competent officers for the engineering branches of the service.

"This meeting believes that by the hearty and loyal co-operation of the Society, which its members are anxious to give, the Dominion Government would have available for advice and assistance at all times, the organized services of the best and most highly-trained engineers in Canada.

"The Society would draw attention to the fact that already about twelve per cent. of its membership have volunteered for the defence of the Empire, but feels that the services of these men have not been used to the best advantage, as many of them have been drafted into other branches of service than the engineers. The Society would impress upon the government the importance of requiring that all engineer officers should have had practical engineering training before receiving commissions."

This resolution was adopted unanimously, and the secretary was instructed to mail it to the Prime Minister. The only comment upon it was made by Prof. W. Muir Edwards to the effect that it must not be overlooked that engineering training is the very best sort of training for an infantry officer to have had, as well as an engineering officer.

The Gzowski medal was awarded to E. Brown, H. M. Mackay and C. M. Morssen for paper on "Tests on the Shearing Resistance of Reinforced Concrete Beams." Many members privately expressed their appreciation of the original research work shown by this paper, by Prof. Herdt's paper on "High Voltage Transmission," by the papers on "Decay in Timber," and by other papers presented during the past year, although some others thought there had been an insufficient amount of such research work done during the year.

G. A. Mountain presented a resolution, which was carried unanimously, advising the Committee on Revision of By-laws to consider a change of name of the Society to embody the word "Institution" instead of "Society," on account of the word "Society" calling to mind social affairs mainly, being chiefly used by such organizations as St. Andrew's, St. George's, etc.

Arthur Surveyer, chairman of the Sanitation Committee, reported that the public health acts of all the provinces had been studied and their good points and shortcomings noted. The committee feels that at least two or more of the persons appointed on any public health board should be corporate members of the Society; that all reports, plans and specifications covering sewerage systems, sewage disposal works, water supply or water purification systems, should be prepared, signed and submitted to the public health board by a corporate member of the Society, and that rules covering the filing of plans should be drafted by the health boards, and should be uniform.

The committee also states that the general plans of waterworks systems should show the locations of source of supply, reservoirs, pumping stations, water purification works, and the whole present distributing system, the proposed extensions, and the provisions for future extensions. That these plans should be accompanied by a descriptive report of proposed works.

The plans for sewerage systems and disposal works should include a topographical plan showing main sewer, collecting sewers, location of outfalls, disposal works, elevations of inverts at all important points. That these plans should be accompanied by a report of proposed works, also on the body of water into which sewage is to be discharged.

A section should be inserted, say the committee, in all public health Acts that a municipality cannot submit to the votes of the electors any by-law to raise money for such works as above without having the board of health's approval, based on the plans and reports submitted.

That a section should be inserted in all public health Acts providing that any municipality ordered by the board of health to do any such works as above be authorized to take the necessary amount from its general funds, and, if necessary, to borrow such amount without formality, and even to exceed statutory borrowing powers by 5 per cent. of municipal valuation.

That control of all water purification plants and sewage disposal works be vested in the Board of Health.

That after these recommendations have been fully studied and adopted, the various Boards of Health should be induced to amend their public health Acts accordingly, if possible.

As regards matters which do not affect health materially, such as pumping capacity, pressure at hydrants, etc., it is suggested by the committee that in order to safeguard the credit of the municipalities, the different provinces should each appoint a Provincial Municipal Board, composed chiefly of engineers, all members of the Society, the duty of this Board being to pass judgment upon all important proposed public works and upon the by-laws presented to raise money before these by-laws are submitted to the ratepayers.

Two hundred and eighteen members attended the annual meeting, which is a slightly smaller number than usual, due undoubtedly to the war. The members who attended from outside the Montreal district included the following, the names being given in order of registration:—

John J. McNab, Trenton, Ont.; A. A. Dion, Ottawa; W. Muir Edwards, Edmonton; L. M. Arkley, Toronto; Harry Barker, New York; G. K. G. Conway, Toronto; E. W. Oliver, Toronto; H. E. T. Haultain, Toronto; B. E. Norrish, Ottawa; R. F. Uniacke, Ottawa; Geo. A. Mountain, Ottawa; G. A. McCarthy, Toronto; George Kydd, Campbellford, Ont.; J. R. W. Ambrose, Toronto; E. T. Wilkie, Toronto; Geoffrey Stead, Chatham, N.B.; A. A. Belanger, Ottawa; C. M. Goodrich, Walkerville, Ont.; B. G. Wisser, Carleton Place, Ont.; Geo. E. Roehm, Walkerville, Ont.; F. C. Gamble, Victoria; F. C. Jewett, Campbellford, Ont.; F. De C. Davies, Winnipeg; Alex. J. Grant, Peterboro'; Charles H. Keefer, Ottawa; J. B. Challies, Ottawa; A. St. Laurent, Jr., Ottawa; A. R. Decary, Quebec; Jean T. Claveau, Chicoutimi, P.Q.; F. G. Engholm, Toronto; Gilbert G. Murdoch, St. John, N.B.; Arthur Vincent, Longueuil, P.Q.; Jean Blizard, Ottawa; P. E. Arnat, Chicoutimi; Col. G. S. Maunsell, Ottawa; James Robertson, Lachine; L. A. Amos, Lachine; Harry A. Paquette, Levis, P.Q.; Wm. P. Anderson, Ottawa; James White, Ottawa; R. J. McClelland, Kingston; J. L. Busfield,

Ottawa; B. S. McKenzie, Winnipeg; J. P. Menard, Lac Long; R. L. Dobbin, Peterboro'; J. B. O. Saint-Laurent, Ottawa; D. H. Woollatt, Walkerville, Ont.; A. B. Lambe, Ottawa; T. A. Jardine-Forrester, Quebec; A. F. Smith, Neilsonville, P.Q.; Gordon Grant, Ottawa; Arthur Dick, Quebec; Duncan Macpherson, Ottawa; H. W. Faus, New York; G. H. Blanchet, Ottawa; A. M. Marraway, Ottawa; H. W. McAll, Toronto; C. H. Fullerton, New Liskeard, Ont.; Andrew F. Macallum, Hamilton; T. A. MacLean, Jr., Marble Mountain, N.S.; J. J. Aldred, St. Catharines; Jas. L. F. Millar, Pembroke, Ont.; D. O. Lewis, Victoria; A. Lighthall, Vancouver; H. Bambrick, Winnipeg; J. G. G. Kerry, Toronto; Jos. R. Roy, Ottawa; S. B. Clement, North Bay; A. B. Blanchard, Truro, N.S.; E. A. Forward, Quebec; C. G. Keyes, Ottawa; H. K. Wicksteed, Toronto; B. W. Seton, Toronto; H. T. Routly, Huntingdon, P.Q.; H. W. Read, Stonehaven, N.B.; W. P. Wilgar, Ottawa; A. O. Beauchemin, Quebec.

HIGHWAY WORK IN CANADA.

MR. GEO. A. McNAMEE, secretary-treasurer of the coming Third Canadian and International Good Roads Congress in Montreal, has collected some interesting information regarding recent progress in highway improvement in Canada. We are indebted to him for the following summary:—

In New Brunswick a separate department for roads has lately been created, with Mr. John L. Feeney in charge, and a definite policy of road construction is being formulated. Last year the province subsidized its roads and will again do so this year.

In Prince Edward Island, which is almost altogether an agricultural province, the earth roads are largely repaired and improved each year. The mileage is approximately 3,500 miles. Repairs are made by district road taxes, supplemented by legislative allowances for larger works. The road taxes for 1914 amounted to $36,000 and the legislative allowance was $18,000 for roads and $35,000 for permanent bridges.

In Quebec, where rapid strides have been made in the last half-dozen years, 295 miles of water-bound macadam and 140 miles of gravelled roads were built in 1915 by the government as provincial roads, or by municipalities with government assistance, at a total cost of nearly $3,000,000. The Sherbrooke-Derby Line road, 32 miles, is complete. There remain only 14 miles to be done on the Levis-Jackman road, and of 32 miles of uncompleted road on the Montreal-Quebec road, foundation has been laid for 21 miles. These roads are expected to be finished this year. From 17,000 to 18,000 miles of earth, gravelled or macadam roads are regularly maintained by municipal councils, 476 municipalities having by-laws in force for road maintenance. During the past few years Quebec has expended over $14,000,000 on its roads out of the $15,000,000 appropriated, and an authoritative rumor states that $4,000,000 will most likely be appropriated during the present session of the Legislature. This, together with the balance of appropriation on hand, makes $5,000,000 for roads in Quebec. Several provincial roads asked for by different districts are receiving government consideration.

In Ontario, 20 miles of the Toronto-Hamilton concrete highway was completed in 1915, leaving about 16 miles to complete. The total cost will be about $850,000; the provincial subsidy being $4,000 per mile. The construction of a main highway from Toronto to Oshawa, about 26 miles, and from Ottawa to Prescott, about 60 miles, at a cost of $600,000, are the principal main roads under consideration. In addition to these projects for main roads which will ultimately form sections of national highways, there was constructed in 1915 approximately 250 miles of county roads at a cost of $658,000, of which the province paid one-third. The provincial appropriation of $2,000,000 for county aid is exhausted, but a further appropriation is expected at the coming session of the Legislature. The Ontario Government proclaimed the Highways Bill to take effect last month. Instead of 30 per cent., the government will pay 40 per cent. of construction cost and 20 per cent. of maintenance cost, instead of nothing as heretofore. The increased revenue from motor licenses will be devoted to defraying the additional charges on the provincial revenue.

The Saskatchewan Legislature voted the following amounts for road purposes for the fiscal year ending April 30th, 1916: To be expended from income, on roads and bridges, $500,000; to be expended from capital, on steel bridges with concrete foundations, $300,000; to be expended from capital, for highway construction, $1,200,000. Owing to financial conditions arising from the war, however, it was decided to restrict the expenditures, and the amounts spent under the above three heads are respectively $170,000, $163,000, and $328,000. The province has not yet started the construction of hard metal roadways, the work consisting mainly of making passable the dirt roads.

Since its formation as a province in 1905, Alberta has been spending $500,000 annually upon its roads, in conjunction with the municipal organizations, and where there are no municipal organizations, expenditure is made directly through the Public Works Department. As the province, like Saskatchewan, is a new one, no highways have yet been set aside for construction with permanent material, the problem so far having been largely one of assisting the settler to get from his homestead to his nearest railway point.

The above brief survey omits reference to the work done or under way in Nova Scotia, Manitoba and British Columbia. It may be stated that in the Province of Nova Scotia the expenditures for highways and highway structures have been greater for the fiscal year ended September 30th, 1915, than for any previous year, according to recent advice from Mr. Hiram Donkin, provincial engineer, Department of Works and Mines.

In Manitoba the year 1915 saw much rural roadwork accomplished under the direction of Mr. Alex. McGillvray, engineer of highways. In that province log-drag competitions have been of phenomenal value in promoting interest in and in improving roads.

British Columbia is considerably in advance of the other western provinces, both in the matter of its road policy and in actual accomplishments. Along the Pacific Coast are to be found some hard-surfaced roads that vie with any in the east in the matter of service, many of them being of an interurban character and others market roads in thickly settled valleys.

Canada has made rapid progress in recent years in the much-needed solution of her transportation problem. It is to be expected that the Congress in March will add materially to the desire for better roads, and although the provinces must be guided in their financial plans this year by consideration of the conditions created by the war, there is a common knowledge that much can be done toward the improvement of rural highways without entailing the expenditure of large sums of money.

CANADIAN SOCIETY OF CIVIL ENGINEERS REPORTS OF BRANCHES.

SEVERAL items of interest and information of value are contained in the reports of branches submitted last week at the annual meeting of the Canadian Society of Civil Engineers. Following are a few brief abstracts from the reports:—

Vancouver Branch.—A. K. Robertson, secretary. Membership, 119. Thirteen meetings were held during the year, papers illustrated with lantern slides being read at each meeting. The principal engineering magazines are kept on file in the library and reading room of the branch, 1017 Metropolitan Building. F. O. Mills has been appointed assistant secretary, as Mr. Robertson is on military duty during a portion of the time. R. F. Hayward is chairman for 1915-1916.

Manitoba Branch.—A. W. Smith, secretary-treasurer. Seven regular meetings of the branch were held during the year, at which papers were read and discussed. The average attendance was forty. The Electrical Section held six meetings, at which the average attendance was thirty-three. The Mechanical Section also held six meetings, with fifteen average attendance. The membership of the branch is 218, with 27 members at the front or enlisted. A volume of transactions of the branch, including papers read in 1914-15, was printed this year and distributed to branch members. A registration list of unemployed members has been started. Frank Lee is chairman for 1916. The branch has a balance of $721.21.

Regina Branch.—J. N. de Stein, secretary-treasurer. This branch is just concluding the first year of its existence. Joint monthly meetings are now held with the Regina Engineering Society, the conduct of the meeting being vested alternately in each society. There have been three such meetings to date, and three other general meetings for organization. The branch members number 25, with eight on active service. The chairman is O. W. Smith.

Victoria Branch. — R. W. Macintyre, secretary. Twelve meetings were held during the year with an average attendance of 13.6, five papers being read before the branch. The membership is 79, a decrease of two compared with the previous year. Nineteen members have joined the Overseas Forces. Eight receptions were held during the winter, with a good attendance of members and ladies. The fourth annual convention of British Columbia members was held in Vancouver, December 10th. Owing to the formation of a Provincial Division, the report of the annual meeting is incorporated with the proceedings of the Provincial Division, which is a nominal change only, as all past conventions have been provincial gatherings of all British Columbia members. H. W. E. Canavan is chairman for 1916.

Edmonton Branch.—L. B. Elliott, secretary-treasurer. Membership, 50. Four papers were read before the branch during the year. The branch also spent several evenings visiting engineering works of interest in the city. The chairman for 1916 is A. T. Fraser. Informal discussions on engineering problems of the day are now being held. A discussion on spur track regulations in Edmonton was held recently. At the last regular meeting, Hon. Charles Stewart, Minister of Public Works of Alberta, gave an address on provincial highways. The meetings have been held at the University of Alberta, and members are also accorded the use of the university library. These matters have been arranged through Prof. Muir Edwards.

Quebec Branch.—Ivan E. Vallée, secretary-treasurer. Membership, 110. Seven meetings were held during the year. Ten members have volunteered for overseas service and one member has been killed in action. S. S. Oliver is chairman of the branch.

Ottawa Branch.—J. B. Challies, secretary-treasurer. Membership, 254, an increase of 26 compared with 1914. Thirty-one members are on active service. Thirteen papers were read before the branch during the year. The Normal School auditorium, the board room of the Conservation Commission, and the Ottawa Public Library, have been placed at the branch's service for open meetings. The branch is somewhat hampered by lack of permanent quarters, but finances are low. John Murphy is the branch chairman for 1916.

Calgary Branch.—Sam. G. Porter, secretary-treasurer. There have been nine general meetings during the year. Seven suppers were given, and illustrated lectures enjoyed after each supper. A luncheon and other entertainment was also accorded various visiting parties of engineers. The bank balance is $365.95. The membership is 67, eight of whom have enlisted, and one member has been killed in action. The report states that it is felt that "the branch has advanced materially during the past year, and that it is exerting an influence in the community. The fact that the city council gave us a grant for use in entertaining a party of engineers who visited the city, and accepted our offer to investigate and report on the technical matters referred to in Alderman Fawkes' charges regarding the Centre Street Bridge, are evidences of the official recognition we have received." The chairman for 1916 is William Pearce.

Toronto Branch.—L. M. Arkley, secretary-treasurer. Membership, 344, an increase of 49 over 1914. Eighteen corporate members and about 75 students have joined the colors. Standing committees were formed paralleling the committees of the main Society. Eight meetings were held, at which papers were read, and a trip of inspection to the Welland Canal was much enjoyed. The branch's library and lecture-room are those of the Engineers' Club of Toronto. Finances are in a fair condition. The chairman for 1916 is Geo. A. McCarthy. Reports of some of the branch committees are appended to the branch's annual report.

British Columbia Division.—E. A. Cleveland, secretary-treasurer. The report includes the minutes of the first meeting of the committee of the provincial division of British Columbia, held October 23rd, 1915, and also of the first general meeting of the British Columbia division held December 11th. 1915. The by-laws have not yet been completed. The Vancouver and Victoria branches have requested the provincial government to amend the "Interpretation Act" by inserting therein a definition of the word "engineer" as a "member of the Canadian Society of Civil Engineers, or of the Institution of Civil Engineers of Great Britain or Ireland, or of the American Society of Civil Engineers." The request has not yet been granted. A circular letter was mailed to all corporate members of the Society regarding the amendments to by-laws and regarding the circular letter on the same subject that had been sent out to the members by the council of the Society. The first chairman of the division is T. H. White.

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The index to Volume 29 of The Canadian Engineer (July to December, 1915), is now ready and will be mailed to any reader upon request.

DEVELOPMENT OF TRANSPORTATION FACILITIES IN BRITISH COLUMBIA

ABSTRACTS FROM THE PRESIDENTIAL ADDRESS OF FRANCIS CLARK GAMBLE, BEFORE THE CANADIAN SOCIETY OF CIVIL ENGINEERS AT THE THIRTIETH ANNUAL MEETING IN MONTREAL LAST WEEK.

BEFORE the advent of the Canadian Pacific Railway there were in British Columbia three cities, *viz.*, Victoria, Nanaimo and New Westminster, the two first situated on Vancouver Island and the latter on the Fraser River, seventeen miles from the Straits of Georgia; the aggregate population of these cities in 1880 was 9,070. Since then, by reason of the greater facilities for transportation afforded by steamships and railway companies with increased mileage and improvement of highways, the industries connected with the natural resources of the country have prospered and extended their operations. The cities, including Vancouver, the Pacific terminus of the Canadian Pacific Railway, and Prince Rupert, the western terminus of the Grand Trunk Pacific Railway, have increased in number to twenty-five, with a total urban population of 203,689 and a rural population tributary thereto, including those living both in organized and unorganized districts, of 188,796, making the total population of the province, according to the public census of 1911, 392,485.

The principal centres of population and of commercial and mining industries are at present along the Canadian Pacific Railway, which enters the province by way of the Kicking Horse Pass, and between that railway and the international boundary line, a zone which, in consequence of the construction of railways and of its close connection with the United States, has attracted up to this time the greatest degree of attention.

Those portions of the province lying north of the Canadian Pacific Railway, known as the Lillooet, Cariboo and Peace River Districts, rich in agricultural and mineral possibilities, have suffered for want of reasonable transportation facilities other than those offered by highways, no matter how good these may be. Roads are necessary as tributaries to railways for comparatively short distances, but to depend upon them for conveying freight or transporting ore long distances does not encourage economic development.

The remedies for this are now being applied. The Grand Trunk Pacific Railway and the Canadian Northern Pacific Railway, two transcontinental lines, enter the province by way of the Yellowhead Pass. The former, proceeding west from Yellowhead Pass, terminates at Prince Rupert on the coast, about 700 miles north of Vancouver, while the latter, turning south, about forty miles west of the Pass, to the North Thompson River, thence follows that stream, and the main Thompson and Fraser Rivers to Vancouver. The Pacific Great Eastern Railway, in course of construction from Vancouver to Prince George, a distance of 479½ miles, connects at the latter place with the Grand Trunk Pacific Railway. It is the intention to extend it north and east into the Peace River country, as far as the east boundary of the province.

(The enormous resources of the province are then referred to by Mr. Gamble, chiefly the water powers, minerals, fisheries, timber, pulpwood, and the areas of agricultural land.)

Coastal and Ocean Service.—After the commencement of the Canadian Pacific Railway in British Columbia, the railway company, upon its entry into Vancouver in 1887, took over the coast service, which was immediately augmented and improved with boats of a superior class, the "Princess" type, and was extended to other island and northern ports, including Skagway and Seattle. In addition to the passenger and freight boats the company employs tugs to tow car barges backwards and forwards between the city of Vancouver and Ladysmith, on the Esquimalt and Nanaimo Railway, Vancouver Island, whereby through freight is delivered to Victoria and other island points in car-load lots, thus avoiding breaking bulk at Vancouver.

The fleet of 21 vessels, including 12 "Princesses," engaged in this service has a total tonnage of 35,591.42.

The Grand Trunk Pacific Railway have in operation between Prince Rupert, Vancouver, Victoria and Seattle, two large passenger ships of the "Prince" class of 3,372

Mount Robson (13,000 ft.) from the C.N.P. Railway.

and 3,379 tons registered respectively. Three other small boats, aggregate tonnage 4,710, are in commission between Vancouver and the northern ports when business offers.

The Union Steamship Company of Vancouver have nine steamships, total registered tonnage 5,529, calling at British Columbia ports between Vancouver and Stewart, the latter being the most northerly port on the coast of British Columbia, situated on the Portland Canal.

The Terminal Steam Navigation Company have three boats, of a total registered tonnage of 1,355, plying between Vancouver and Howe Sound ports. There are several other boats engaged in the coastwise service, but in number and size they do not call for special mention here.

The total number of boats and the registered tonnage thereof, as outlined above, engaged in the coastwise service of the province, are 38 and 43,936 respectively.

The trans-Pacific trade is of great interest. There has been a notable advance since 1880, when the tonnage was insignificant. In 1887, following the opening of the railway between the Atlantic and the Pacific, the Canadian

Pacific Railway established a line of steamships between Vancouver and oriental ports, consisting of three ships, approximately of a total gross tonnage of 10,000. The service was every three weeks both ways. In 1889 three ships of the "Empress" class entered the service, replacing those first mentioned; in 1893 two larger "Empresses" were put in service. Had it not been for the war there would now be five large steamships of a gross tonnage of 51,720 tons running between Vancouver and Yokohama and Hong Kong.

The Canadian-Australian line was established in 1893, with two steamships of a gross tonnage of 6,421, augmented, at this date, to 21,490 tons. One of these boats leaves Victoria, B.C., and Sidney, Australia, every twenty-four days for Sidney, Australia, and Vancouver, B.C., respectively, calling en route at Honolulu, Suvo, Fiji and Auckland, and New Zealand.

Two other lines of steamships, the Blue Funnel and Harrison lines, freight carriers principally, make voyages between the ports of Great Britain and those of the province, via the Suez Canal or by way of Cape Horn, or by the Panama Canal, when again open to traffic, calling both at Vancouver and Victoria.

Bridge No. 3 Over Thompson River at Lytton, B.C., C.N.P. Railway.

Two lines of steamships, one called the Asaka Shosen Kaisha, with four boats of 12,000 tons each, and two boats of 18,000 tons each displacement, totalling 84,000 tons; and the Nippon Yusen Kaisha, with three boats of 13,000 tons each and three boats of 12,500 tons each displacement, totalling 76,500 tons, call about every two weeks at Victoria on the voyage from Yokohama to Seattle.

It is interesting to note the number and tonnage of ships entering inwards and outwards from the ports of the province, in 1880, 1889 and 1915, a period of 35 years:

	Ships.	Registered tonnage.	Foreign.
In 1880:—			
Inwards:	471	356,640	71%
Outwards:	465	353,687	74%
In 1889:—			
Inwards:	1,261	1,312,988	84%
Outwards:	1,313	1,175,567	85%
In 1915:—			
Inwards:	4,453	4,578,405	45%
Outwards:	4,448	4,582,982	44%

It is encouraging also to note by the above figures that while vessels of foreign origin were largely in excess of those of British origin in 1880 and 1889, the position in 1915 has been reversed, British ships outnumbering the foreign.

The Dominion Government, aided by the Imperial Government to the extent of £50,000 granted with the condition that the fleet should have the preference in docking over any other ships, constructed in the 80's a graving dock at Esquimalt. The dimensions are:

Length, with gate at outer invert	481	feet
Width at entrance	65	"
Depth on sill (extreme)	30	"
Least water on sill at low tide	17	" 6 inches

As shipping increased the necessity for greater facilities for making repairs arose, and to meet this, marine railways or slips were constructed from time to time.

One of these is situated at Esquimalt, lately acquired by Yarrows, Limited. The dimensions are:

Total length on keel blocks	55 feet
Dead weight capacity	2,500 tons

Another was built in Victoria harbor by the Victoria Machinery Depot, of which the dimensions are:

Length	280 feet
Width	50 "
Dead weight capacity	3,000 tons

In Vancouver harbor, south side, the B.C. Marine, Limited, has a slip of the following capacities:

Length of vessel	250 feet
Width of slip	52 "
Dead weight capacity	1,500 tons

On the north side of Burrard Inlet the Wallace Ship Yards have two marine railways of the following capacities:

(a)	Length of vessel	260 feet
	Width of slip	52 " approx.
	Dead weight capacity	2,000 tons
(b)	Length of vessel	150 feet
	Width of slip	52 " approx.
	Dead weight capacity	1,000 tons

The Grand Trunk Pacific Railway Company lately built at Prince Rupert a floating dry dock. It is in three sections, of which the dimensions are as follows:

Centre Section: Length 270' x 100' in width.
Lifting capacity .... 10,000 tons
Each end Section: 165'
each,
Length 330' x 100' in width,

Total length ..... 600'

Lifting capacity, 5,000 tons each .... 10,000 tons

Total lifting capacity .... 20,000 "

It is equipped with twenty-four 12-inch centrifugal electrical pumps.

The Dominion Government have now in contemplation the construction of another graving dock at Esquimalt of much greater dimensions than the first one.

Mr. Gamble then prefaces his consideration of land transportation by taking up the natural divisions by mountain ranges and by rivers, outlining physical features and pointing out the leading resources of each division.

Early Land Routes.—Before the Canadian Pacific Railway began operating through British Columbia as a transcontinental railway (the first in Canada) in 1885, there were no commercial railways in the province. Supplies were transported to the interior of the mainland over trails, by pack trains of mules or horses, and sometimes on men's backs; and afterwards by freight wagons hauled by bull, mule or horse teams, over the wagon road from Yale to Barkerville in Cariboo, a distance of about 432 miles.

The construction of the Cariboo Road was commenced through the canyon above Yale by royal engineers in 1862, who built about eight miles. After this, the work was given out by contract by the Crown Colony Government, and the road completed to Barkerville.

When navigation on the Fraser River was possible, freight was transferred to steamers at Soda Creek and carried to Quesnel, a distance of about 54 miles.

The suspension bridge over the Fraser River (220-ft. span) was built by contract in 1863, the contractor being allowed to collect tolls. The cables of this structure, made of black iron wire brought from San Francisco, were laid together on the ground covered with canvas and painted. The towers were of timber resting on masonry. It was in use for forty-seven years.

There was an alternative route into Cariboo, in the early days before the Yale-Cariboo Road was built, by way of the Fraser River, Harrison River, Harrison Lake, Douglas Portage, Lillooet Lake, Portage to Anderson Lake, through the latter and Seton Lake by boat, and thence by road to Lillooet and up the Fraser River over Pavilion Mountain, over 5,000 ft. altitude, to Clinton, where a junction with the Cariboo trail was made. This route was abandoned after the completion of the Yale-Cariboo Road, on account of the excessive cost, the consequence of many unavoidable delays due to necessary transhipments.

A branch stage road was built in 1866 from the Cariboo Road at Cache Creek to Savona on Kamloops Lake, through Kamloops to Okanagan Mission, situated on the east side of Okanagan Lake, and in 1869 a stage line was established between Clinton and Lillooet.

To assist in the construction of the C.P.R. the government of British Columbia transferred to the Dominion Government a strip of land called the Railway Belt, 40 miles in width (20 miles on each side of the centre line of the railway), from a little east of the 123rd meridian to the summit of the Rocky Mountains, containing about 11,050,000 acres, together with a block of land in the Peace River country bordering on the 120th meridian, the east boundary of the province, between north latitudes 55.38 and 56.40 containing 3,500,000 acres.

Since May, 1880, when the construction of the Canadian Pacific Railway was commenced in British Columbia by the Government of Canada, over 2,000 miles of railway have been completed and put in operation in the province, including Vancouver Island; 411 miles are now under construction and 949 miles projected.

The Canadian Pacific Railway.—It has never been definitely explained why the Kicking Horse Pass was selected in the first instance by the Canadian Pacific Railway Company in preference to the Yellowhead Pass, some 1,479 ft. lower, but whatever the reason the fact remains that it has proved a wise and fortunate one for the country through which the railway now passes. Mining districts have been prospected and many mines opened up, and fertile valleys settled and developed that otherwise would have remained untouched for very many years.

The Dominion Government in 1880 let the contract for the construction of that portion of the railway lying between Emory Bar, about four miles below Yale, through the canyon of the Fraser, to Savona at the lower end of Kamloops Lake, a distance of about 123 miles. Work began in May of that year. A contract was let subsequently to the same contractor to build from Emory Bar west to Port Moody, the statutory terminus, a distance of about 105 miles. The track between Port Moody and Savona was laid first with 56-57-lb. steel rails in 1884-5. These two portions were handed over upon completion to the company.

The railway company entered upon construction in British Columbia probably in the fall of 1883, working east from Savona and west from the summit near Field. The last spike closing the connection between east and west was driven near Craigellachie, in Eagle Pass, 351 miles west of Vancouver, by Mr. Donald Smith (afterwards Lord Strathcona), on the 7th November, 1885.

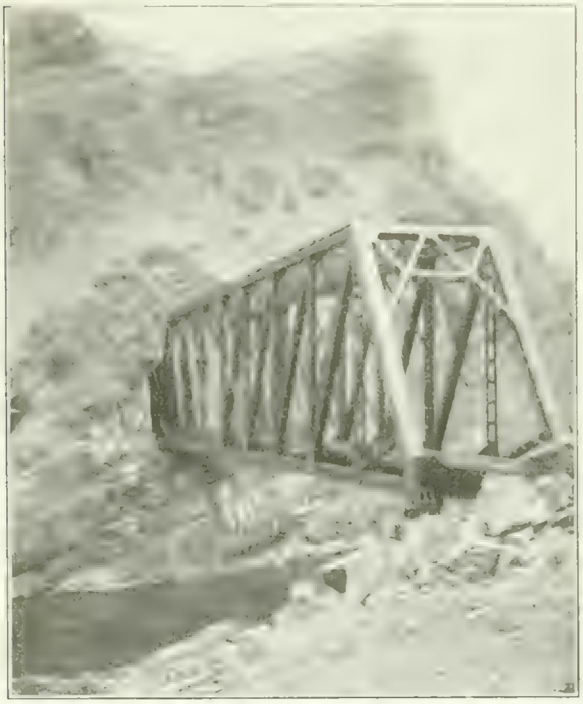
Trout Creek Bridge, near Summerland, West of Okanagan Lake. Centre Span, 250 ft.; Maximum Height, 236 ft.

The railway company extended the line west from Port Moody along the south shore of Burrard Inlet to Coal Harbor, the first through train arriving in Vancouver on the 23rd May, 1887.

From the year 1886 the Canadian Pacific Railway Company has steadily pushed into the territory tributary to, and south of, the main line by constructing branches

or by leasing and absorbing the provincial charters of other railways, whereby fertile valleys and mineral resources lying between the main line and the international boundary line have been developed. The company between Vancouver and Ruby Creek has 92 miles of double track.

The transcontinental line of the railway company enters the province by way of the Kicking Horse Pass at the summit of the Rocky Mountains, follows down the Kicking Horse River to Golden on the Columbia River, thence follows that stream to Beaver Mouth, ascending from there to Roger's Pass, the summit of the Selkirks, descending again following the Illecillawaet River to Revelstoke on the Columbia River, rising therefrom, the line passes through Eagle Pass, descending to Shuswap Lake, and thence following the valleys of the Thompson and Fraser Rivers to Burrard Inlet and Vancouver, a distance of 521 miles.



Canadian Northern Pacific Railway Bridge No. 5, Over Thompson River, at Ashcroft, B.C.

The weight of rails first laid from Kicking Horse summit to Revelstoke was 70 pounds, from Revelstoke to Savona, 60 pounds. These have all been replaced with 85-pound rails with improved angle bars, and tie plates.

The ruling grades are as follows:—

East Bound:—

Cascade Section:—	
Port Moody, 2 miles east	1.1%
Katz Landing to Hope, 3 miles	1.2%
Sailor Bar to Spuzum, 4 miles	1.2%
Thompson Section:	
Salmon River to Keefer, 4 miles	1.1%
Shuswap Section:—	
Stormont to Notch Hill, 9 miles	1.1%
Craigellachie to Clan William, 10 miles	1.1%
Mountain Section:—	
Revelstoke to Albert Canyon, 20 miles	1.2%
Albert Canyon to Rogers Pass, 20 miles	2.2%
Golden to Leanchoil, 15 miles	1.7%
Otter Tail to 2 miles west of Field, 4 miles	2%
Field to Tunnel, 2 miles	2.2%
Tunnel to Kicking Horse Lake, 5 miles	4.5%
Kicking Horse Lake to Hector, 2 miles	2%

West Bound:—

Mountain Section:—	
Field to 2 miles west	2%
Beaver Mouth to Rogers Pass, 23 miles	2.2%
Shuswap Section:—	
Revelstoke from Columbia River Bridge to Clan William, 8 miles	1.3%
Tappin Siding to Notch Hill, 8 miles	1.3%
Thompson Section:—	
Penny's Grade, 3 miles	1.1%
Cisco, 2 miles	1.1%
Salmon River west, 2 miles	1.1%
Cascade Section:—	
2 miles east to Spuzum	1.1%
1 mile east to Yale	1.1%
1 mile east of Hope	1%

One notable betterment is the great reduction which has been carried out on the hill between the tunnel and Kicking Horse Lake, whereby the 4.5% grade has been reduced to 2¼% grade, but lengthening the line four miles with the assistance of two spiral tunnels.

Another very important improvement in the location of the line is at present in progress at Roger's Pass, whereby the 2% grade, compensated, ascending westwards to, and descending from the summit of Roger's Pass, will be very greatly reduced, the line shortened by 4.3 miles and about five miles of snow sheds avoided. This change entails a tunnel, double tracked in anticipation of future needs, five miles in length, one of the longest, if not the longest, on the continent. The grade reduction is the difference in elevation between the summit of the Pass and that of the highest point in the tunnel near the west portal, namely, 552.6 ft.

Entering the east portal the grade rises .95% for a distance of 4¾ miles, then follows a quarter of a mile of level grade to the west portal, the grade therefrom falls for three-quarters of a mile at the rate of .50% and thence at 2% compensated, to connection with the original main line where the grade is the same.

The diversion commences 76.55 miles west of the divisional point at Field and terminates at 87.05 miles.

The bridge erected by the Dominion Government over the Fraser River at Cisco, 152 miles east of Vancouver, was a cantilever type designed by Mr. Snider, of New York, fabricated at Birmingham, England, shipped to Esquimalt and erected in place by the San Francisco Bridge Company in 1884. It was the first bridge of this kind designed for railway purposes.

Previously to being shipped, it was put together at the shops and was there seen by some engineers who ordered a similar structure for the Niagara River below the Falls. It was manufactured of iron and shipped, and was erected before the Cisco bridge, so that although the latter was the first railway cantilever bridge made it was not the first erected.

The total length of the bridge was 529 feet, ballast wall to ballast wall of abutments, the centre span being 315 feet centre to centre of piers.

The traffic becoming heavier, the weight of the locomotive was increased from 100 to 200 tons. It was thereupon decided to replace the cantilever bridge with a steel through truss centre span and deck shore spans. This replacement was carried out without any interruption to traffic by the Dominion Bridge Company. The old bridge has been re-erected over a deep ravine on the Esquimalt and Nanaimo Railway within a short distance of Victoria.

The paper then reviews the history of the construction, and of the development resulting therefrom of the various branch lines and extensions of the C.P.R. in British Columbia, with particular reference to the Kootenay Central Railway; the Revelstoke-Arrowhead-

Nakusp-Kalso system; the Shuswap and Okanagan Railway; the Crow's Nest extension, the Kettle Valley Railway, the Esquimalt and Nanaimo Railway, and others.

The Canadian Northern Pacific Railway.—The Canadian Northern Pacific Railway Company was incorporated by an Act of the Legislature of British Columbia in 1910. By a previous Act an agreement confirmed by an Act had been entered into whereby the government of the province agreed in consideration of the company building 500 miles on the mainland, and 100 miles from Victoria on Vancouver Island, to guarantee the company's bonds to the extent of $35,000 per mile, 600 miles in all. The guarantee of bonds for the 500 miles on the mainland was afterwards increased by $10,000 per mile. Further undertakings by this company received assistance from the province in the shape of guaranteed bonds as follows: 339 miles of branch lines and extensions at $35,000 per mile; 11 miles Westminster Bridge to Vancouver, at $10,000 per mile; 6 terminals, Port Mann, Westminster, Vancouver, Patricia Bay and Victoria. Lump sum, $10,000,000.

The line on the mainland has been completed and is now in operation from Yellowhead Pass to Westminster bridge, and thence over the tracks of the Great Northern Railway Company to Vancouver.

The Canadian Northern Pacific Railway enters the province of British Columbia through the Rocky Mountains at Yellowhead Pass, from thence paralleling the Grand Trunk Pacific Railway, on the south side thereof, it follows the Fraser River, Mt. Robson to the right, to Tete Jaune Cache for a distance of about 42 miles, thence turning south, it passes over Albreda Summit—there are seven steel bridges between Yellowhead and this summit—to the North Thompson River, which it follows to Kamloops, crossing the same in its course four times. From Kamloops paralleling the Canadian Pacific Railway generally on the opposite side of the river it continues down the Thompson River, crossing it seven times, and the Fraser River, crossing it at two points, to New Westminster, thence over the Provincial Government bridge at that place, it proceeds to Vancouver, as before stated, over the tracks of the Great Northern Railway, a total distance of 511 miles. All the bridges over the Thompson and Fraser Rivers have steel superstructure resting on concrete piers and abutments. One span on the North Thompson River above Kamloops has a vertical lift span.

The Pacific Great Eastern Railway.—The Pacific Great Eastern Railway, now under construction between Vancouver and Fort George, where it will form a connection with the Grand Trunk Pacific Railway, has a length of 479.6 miles. Its initial point is on the north short of Burrard Inlet, where it will connect with the proposed bridge over the Second Narrows of that sheet of water.

At the present time it is constructed between Lonsdale Avenue, in the city of North Vancouver, and a point called Whytecliffe, 13 miles west of the shores of Howe Sound. Between Whytecliffe and Squamish (a distance of 27 miles), the present terminus of the railway, no work of construction has been performed. From Squamish the line follows up the Cheakmus River to the summit at Green Lake. From Mons or Green Lake the line descends to the Lillooet River, Pemberton Meadows, 58 miles from Squamish dock. From the Lillooet River the line ascends over Birkenhead Summit, then descending to Anderson Lake, skirting its north shore and that of Seaton Lake, to Lillooet on the banks of the Fraser River. From Lillooet the line follows up the east side of the Fraser River on a grade of 2% and 2.2% for about 28 miles to Kelly Lake summit, and thence on to Clinton, a distance of 167 miles from Squamish. From Clinton, to which point the line is now being operated from Squamish dock the direction is northeasterly to Horse Lake summit. From Horse Lake summit the line turns to the northwest and skirts the shores of Lac la Hache on the south side to the divisional point at Williams Lake, thence passing Quesnel, returning to the Fraser River it continues on the east side thereof to the Grand Trunk Pacific bridge on the Fraser River opposite Prince George. The Pacific Great Eastern Railway, when finally finished, will open up one of the most desirable sections of British Columbia.

Yellowhead Pass from the Summit of Mount Resplendent (8,000 ft.), Showing C.N.P. Lines on Extreme Left; G.T.P. Parallel to it and Fraser River on Right.

From Prince George it is proposed to extend this railway northwards and westerly to the Peace River country, where it is anticipated connection will be made with one of the roads in the northern part of Alberta.

Grand Trunk Pacific Railway.—The Grand Trunk Pacific Railway (transcontinental line) enters British Columbia by way of Yellowhead Pass paralleling the Canadian Northern Pacific Railway down the Fraser River to nearly Tete Jaune Cache, a distance of 42 miles, from this point it continues down the Fraser, which it crosses, into Prince George, thence running up the Nechacco River to Fraser Lake it passes through the Bulkley Valley to the Skeena River, about Hazleton, thence down that river to its estuary which it follows along the north shore line to the terminus of the railway at Prince Rupert, a distance of 703.4 miles.

Bridge No. 10 Over Thompson River at Kamloops, B.C., C.N.P. Railway. Note Vertical Lift Span.

The ruling grade westbound is .4 of 1%. The maximum grade is the same. The ruling grade eastbound is the same; the maximum grade eastbound is 1%, 20.15 miles in length, and designed as a pusher grade. Outside

of the 20.15 miles mentioned all eastbound grades are .40 of 1% or less. The maximum curve in British Columbia is 6 degrees.

At Prince George, where connection will be made with the Pacific Great Eastern Railway, another transcontinental road will be admitted into Vancouver.

Great Northern Railway.—The Great Northern Railway Company, incorporated in the United States, controls in the province of British Columbia all the lines constructed under charter guaranteed by the Provincial Legislature to the Vancouver, Victoria and Eastern Railway and Navigation Company; the Crow's Nest Southern Railway; the Victoria and Sidney Railway; the Victoria Terminal Railway & Ferry Company, and the New Westminster Southern Railway; the Red Mountain Railway which is a branch of the Spokane Falls & Northern Railway from a point south of the boundary line to Rossland in British Columbia; the Fort Shephard and Nelson Lake Railway from the boundary line to Nelson, B.C.; the Vancouver, Westminster & Yukon Railway, approximately 420 miles in length. The terminus in this province is Vancouver. With the exception of the Victoria and Sidney Railway, all the lines mentioned above lie between the Canadian Pacific Railway and the international boundary line. This railway system brings the northern portion of the province into close touch with the United States.

Bridge Over the Fraser River at New Westminster, Built by the British Columbia Government.

The most easterly point of the Great Northern Railway Company in British Columbia is Michel on the Crow's Nest Southern Pass. From Michel the line proceeds down the Elk River, passing Fernie and paralleling the Crow's Nest line of the Canadian Pacific Railway to Elko, where the latter line crosses under the one now under reference. From Elko this road proceeds in a southwesterly direction to Kootenay River and crosses into the United States at a place called Gateway. Thence, after meandering through the States of Idaho and Washington it returns to Canada: (1) At Waneta on the east side of the Columbia River at the boundary line; (2) at Paterson on the east side of the Columbia River; (3) at Laurier. From Laurier it runs on the north side of the boundary line through British Columbia, passing Grand Forks, with the branches to Granby and Phœnix, leaving the province again at Carson, returning to the north side of the boundary line at Midway and leaving it again about Bridesville, returning to the north of the boundary line at Chopaka on the Similkameen River, thence following up the Similkameen River to Princeton and on to Otter Summit. From Otter Summit the V. V. & E. Railway and Navigation Company (Great Northern Railway Company) has running rights over the Kettle Valley Railway to Hope on the Fraser River, then having the same rights over the Canadian Northern Pacific Railway to Sumas, and thence through the southern part of New Westminster district to the bridge over the Fraser River at New Westminster, and then on to Vancouver.

The bridge over the Fraser River was built by the province of British Columbia and was operated for traffic in the year 1904. It gives access to Vancouver for three transcontinental railways, namely, the Great Northern Railway, the Northern Pacific Railway, and the Canadian Northern Pacific Railway.

British Columbia Electric Railway.—The British Columbia Electric Railway Company has also running rights over this bridge. This company was incorporated in 1897, and immediately took over the operation of electric tramways and light and power services in the cities of Victoria, Vancouver and New Westminster, and the adjoining territory. The present mileage of single track, including city and suburban lines, is 281 miles, in details as follows:

Vancouver Island	51 miles
Mainland	230 "
	281 "

The above-mentioned bridge is a steel structure resting on solid masonry piers consisting of the following spans:

1 through fixed span of 225′
1 " " " " 380
1 " swing " " 380′
5 " fixed spans of 159′ each.

The approaches to the spread span on the north side:

East Railway Approach:

1 deck-plate girder skew span 90′
2 through plate girder skew spans of 53.5′ each
1 deck-plate girder skew span 41′

West Railway Approach:

1 deck-plate girder skew span 71.5′
1 through plate girder skew span of 43′
1 " " " " " " 38
1 deck " " " " " 32′

The highway floor is on the upper chords of the bridge. On the north side the approach consists of three deck plate girder spans of 57.5 ft. each.

Steel bents are used to support all railway spans that cross railway tracks of the Canadian Pacific Railway and the Great Northern Railway; and also the three highway spans at the north end of the structure. The clear roadway for both the railway and highway is 16 ft.

The approach on the south side is by means of a wooden trestle crossing over the Great Northern Railway line, and makes all necessary connections.

In our issue of January 20th there appeared an article on the Welland Ship Canal, in which it was stated that certain excavation work had been done by "an 85-Ton Marion-Osgood Shovel." As the corporate name of Marion Osgood Company was some time ago changed to The Osgood Company, this should have read "an 85 Ton Osgood Shovel."

INDEX TO VOLUME 29.

The index to Volume 29 of The Canadian Engineer (July to December, 1915), is now ready and will be mailed to any reader upon request.

IMPORTANT CANADIAN WATER POWER QUESTIONS.

At the recent meeting of the Commission of Conservation, Mr. Arthur V. White, consulting engineer to the Commission, reported, in part, as follows concerning water interests of Canada. Last year's annual report contains a comprehensive statement respecting certain very important water problems with which the Commission is especially concerned; as, for example, the proposed development of power on the St. Lawrence River at the Long Sault Rapids; the unauthorized diversion of water from the Great Lakes system by means of the canal of the Sanitary District of Chicago; and the hydro-electric power developments at Niagara Falls.* A brief reference may here be made to the present state of affairs in connection with such problems.

Long Sault Rapids, St. Lawrence River.—As is known, the Long Sault Development Company, of New York, has had its charter, granted by the State of New York, declared, by the governor and by the attorney-general of the State, to be unconstitutional. The company has filed application with the Supreme Court of the United States, with the object of having its case reopened before that tribunal, in order, if possible, to secure a re-establishment of its status with respect to its former charter. It was expected that the case would be tried at Washington, D.C., in the October term of 1915, however, it will probably not come up for hearing until March, 1916. The Commission of Conservation is keeping informed upon this matter.

Water Diversion by Chicago.—The Sanitary District of Chicago, it may be recalled, has been diverting from the Great Lakes system into the Mississippi River, more than double the quantity of 4,167 cubic feet of water per second—the amount authorized by permit of the United States Secretary of War. The attorney-general of the United States has brought a suit against the Sanitary district, which action is being tried in the District Court of Chicago.

This action has been referred to, by some persons in the United States, as a "friendly suit," the signification of the phrase as thus used being: that inasmuch as it was anticipated such suit would involve the taking of a great deal of technical testimony, it was considered desirable, in order to finally save time in the Supreme Court, to develop the case and have the testimony submitted in one of the lower courts and then, subsequently, the case could be submitted largely in printed form for the consideration of the higher court.

As the quantity of water, which is being diverted by the Sanitary District, is avowedly a transgression of its permit from the United States War Department, many Canadians who have been interested in this matter have been perplexed when trying to understand why it has been necessary to develop such a prolonged and extensive technical case, when the fundamental fact at issue, *viz.*, the diversion of the water in direct violation of the government permit authorizing same, is so outstanding a fact that it can scarcely be made more cogent by technical or other special evidence.

With regard to the additional carrying capacity of the newer canal, known as the Calumet-Cutoff, it has been understood that the United States Secretary of War authorized the construction of this new canal, subject to the provision that as a result of such construction, the total diversion of water through both the Chicago and Calumet rivers together, should not be greater than would otherwise be diverted, or become legal to divert, through the Chicago River alone. In view of the fact that the Chicago Drainage Canal has been designed so that, from the physical standpoint, it could carry from two to three times the quantity of water authorized by the permit of the United States Secretary of War, it would appear that there could scarcely be satisfactory justification for constructing a large additional channel like the new Calumet-Cutoff. Once such large channels are actually constructed, the requests for additional water may be expected to become more and more insistent, or the water may even again be taken in defiance of authority. Obviously there will always be greater danger of having water diverted with consequent danger to the interests entitled to use it in its natural channels, than would be the case if channels admitting of such diversion were not created. Consequently the construction of such channels as the Calumet-Cutoff can hardly be considered as other than a serious additional menace.

Diversions from St. Croix River, New Brunswick.—Speaking of diversions from boundary waters, it may be stated that the Commission of Conservation, in 1915, had brought to its attention an actual diversion of boundary waters, without proper authority, on the St. Croix River, which, as is known, constitutes, for a portion of its length, the international boundary between the Province of New Brunswick and the State of Maine.

Briefly stated, the facts are as follows: United States financial interests controlling the St. Croix Paper Company of the State of Maine, and operating through two allied companies—one the St. Croix Water Power Company, chartered in 1899 by special act of the Legislature of the State of Maine, and the Sprague's Falls Manufacturing Company, Limited, chartered in 1902 by special act of the Parliament of Canada—secured control of the two most valuable power sites on the St. Croix River; one at Sprague's Falls, the other at Grand Falls. The electric energy capable of development aggregates some 25,000 horse-power and is to be used entirely on the United States side for the operation of pulp and paper mills located at Woodland, Maine, where a thriving community, claiming a population of 1,500 to 2,000 has, as a result of this power, already been built up.

At Sprague's Falls the rated capacity of the power plant is about 12,000 to 14,000 horse-power. Another plant situated near Grand Falls, about ten miles above Woodland, has recently been completed with an additional rating of 12,000 to 14,000 horse-power, which is to be transmitted to Woodland in order to increase the capacity of the company's plant there located. It has been stated that the property of the St. Croix Paper Company, exclusive of their extensive timber holdings, represents an investment of over $3,500,000. The average net earnings of the company during recent years is stated to be over $300,000 per annum.

Now, in order to develop this power at Grand Falls, the company constructed a large canal lying, and extending for nearly a mile, entirely within the State of Maine. By means of a dam erected across the international boundary at Grand Falls, an artificial lake has been created so as to enable the water of the St. Croix River to be diverted, by the canal, into the United States for the development of power at the Grand Falls power house. At its lower stages the total flow of the St. Croix River—an international boundary stream—will be diverted into the United States.

The Commission of Conservation being requested to report upon this diversion, the assistant to chairman, Mr. James White, appeared before the International Joint Commission and presented, on behalf of the Commission

* See *The Canadian Engineer* for February 11th, 1915 page 238.

of Conservation, a memorandum objecting to the diversion; also requesting that the use of Canada's share of the waters of the St. Croix River be only permitted on such terms, including time limit, as would ensure that the Province of New Brunswick or the Dominion of Canada would receive reasonable compensation for the use of Canada's waters; and, further, that Canada's equity in the waters, *per se*, be inalienably preserved.

The time will come when Canada will have uses for her share of all such water powers. One element of danger which the Commission of Conservation emphasized in connection with the diversion of waters like those of the St. Croix River into the United States, was that while the International Boundary Waters Treaty contemplates the possibility of certain "temporary" diversions, yet, unless the terms and conditions of such temporary diversions are explicitly understood and specified, and means taken to render the diversion only a "temporary" one with respect to time, there may be an effort later, on the part of interested parties, to claim that the diversion had resulted in the establishment of vested interests, and should *now* be regarded as of a more or less permanent, rather than a temporary character.

Niagara Power Development.—A year ago it was pointed out in connection with power development that a complex situation exists along the Niagara River, more particularly in the vicinity of the Falls.

Attention was drawn to two Bills—the Cline Bill and the Smith Bill—presented to the United States Congress, both of which measures contain features which, if enacted into law, would have an important effect upon Canadian interests.

In last year's report attention was drawn to the opinion delivered by the Public Service Commission of the State of New York, and quoted the Commission as representing:

> That there is a large shortage of electric power in western New York, with a strong demand for greater supply which is not being met by existing companies. . . . We are using all the power made on the New York side, and all that has been brought from Canada, and the demand for more power in western New York is insistent and being urged with great force.

And it was also stated that it had been urged; if the importation, into the United States, of power from Canada were prohibited it "would plainly amount to a great public calamity."

All these facts indicate that the time has arrived when the strongest possible efforts will be made to secure more and more use, for power purposes, of the waters of the Niagara River.

In the United States there are a number of public organizations already actively interested in securing additional development of Niagara power.

The Joint Legislative Water Power Investigating Committee, appointed by the Legislature at Albany, under the chairmanship of Senator George F. Thompson, has recently (December, 1915) been holding power hearings in New York City and elsewhere.

At these hearings, the president of the American Civic Association, as reported in the daily press, stated that "the Thompson committee were looking for testimony which could be distorted into an excuse for a development of vast importance to the city of Niagara Falls, at the expense of the State and nation."

The Hydro-Electric Association of Niagara Falls has been holding meetings and drafting proposed legislation which, it is stated, will be presented to the New York Legislature for approval early in 1916. This organization seeks the use of the 4,400 cubic feet of water per second available in the United States under the International Boundary Waters Treaty, but which has not yet been apportioned.

New York financial interests have had engineers exploiting and making representations to government departments in the United States, respecting schemes for the proposed development of power by means of dams in the lower Niagara River.

The Federal Light and Power Company, of Detroit, it has been stated, have just secured a permit from the United States Federal Government permitting the importation of Niagara power via Canada to Detroit.

Hearings respecting Niagara power have been held before the United States House of Representatives Committee on Foreign Relations. Bills such, for example, as the Smith Bill and the Cline Bill, have been under discussion by this important committee.

Hydro-Electric Power Commission of Ontario.—The growing market for Niagara power in Canada is strikingly emphasized by the success of the undertakings directed by the Hydro-Electric Power Commission of Ontario. Recently the chairman of the Commission, Sir Adam Beck, in drawing attention to the fact that the government transmission lines now carrying from Niagara a load of 110,000 horse-power, said that he could not help recalling the time when the late premier, Sir James Whitney, told him that "the Commission would not require 10,000 horse-power." As a matter of fact, the markets for the Commission's power have developed so rapidly that the Commission itself has been compelled, earlier than was anticipated, to seek diligently for new sources of power.

The chairman of the Commission has stated that there can be made available some 6,000 to 6,500 cubic feet of water per second out of the unappropriated portion of the 36,000 cubic feet per second allotted to Canada under the Boundary Waters Treaty. The Commission proposes that this surplus be utilized by it under a head of some 300 to 305 feet, resulting, in round figures, in the development of some 200,000 horse-power. The water would be conveyed from the vicinity of Chippewa Creek to, and discharged near, Queenston.

All the electric companies developing at Niagara Falls have found that their market demands have exceeded their expectations. Over 100 Ontario municipalities are now supplied by the Hydro-Electric Power Commission; and in January, 1916, another reduction was made in electrical rates, resulting in the saving of from 3 to 20 per cent. to consumers in about 60 municipalities.

Rural customers—not necessarily meaning in every case farmers, but rather small rural consumers—being supplied, now number some 700 to 1,000.

Last fall the Hydro-Electric Commission placed in operation its new plant at Eugenia Falls, Ontario, having a possible capacity of 8,000 horse-power, half of which is already installed. Ten or twelve municipalities are being supplied from this plant. Other municipally owned plants are to be constructed.

During the past year the first government-owned electric railway in Canada, known as the London and Port Stanley Railway, was placed in operation by the Commission. A summary of the first half year's operation ending December 31st, 1915, shows a gross revenue of $145,737.84, a net expenditure for operating expenses and fixed charges, etc., of $136,460.20, making the net earnings for the half year of $10,277.64. Freight appears to be the important factor in ensuring profitable returns for such roads.

In the municipal elections held in January, 1916, all the larger municipalities concerned, including the cities of Toronto and London, passed a by-law involving a possible expenditure of some $14,000,000 to provide a government-

owned systems of hydro-radial railways, the trunk line of which will run from Toronto to London. Such railway systems will require much additional power.

These facts just cited are offered by way of further emphasizing the great economic importance to Canada of power like that obtained from Niagara. The larger portion of southwestern Ontario is now dependent for power and lighting on the hydro-electric developments at Niagara.

Problems corresponding to those associated with these Niagara developments, involving as they do the question of the exportation of electrical energy, are of vital importance to the whole Dominion, and are worthy of the best statesmanship which Canada can bring to bear upon them.

Investigation by International Joint Commission at Lake of the Woods.—What is known as the Lake of the Woods investigation is being conducted by the International Joint Commission, under the Boundary Waters Treaty, of 1909, between Great Britain and the United States. The chief purpose of the investigation is to secure the most advantageous use of the waters of the Lake of the Woods and of the waters flowing into and from that lake on each side of the boundary for domestic and sanitary purposes; for navigation and transportation purposes; for fishing purposes, and for power and irrigation purposes; and also to secure the most advantageous use of the shores and harbors of the lakes and the waters flowing into and from the lake. This object is sought to be attained by means of regulating the lake between certain desired and yet-to-be-determined levels.

Through the courtesy of the Commission of Conservation, and upon request by the Canadian Commissioners of the International Joint Commission, arrangements were made for the writer to have whatever time would be necessary to fully attend to the duties of this important investigation.

The total area of the territory which drains its waters into the Lake of the Woods is 26,750 square miles, of which 15,565 square miles, or 58.2 per cent. are in Canada, and 11,185 square miles, or 41.8 per cent., are in the United States. Of this 26,750 square miles, 3,960 square miles, or 14.8 per cent., is water area, of which 70 per cent. is in Canada, and 30 per cent. in the United States.

Comparatively few persons have any adequate appreciation of the extent and value of the great inland water resources of portions of Canada. In this connection a few brief statements, having the Lake of the Woods watershed in mind, will doubtless be of interest.

The extent of the area of the Lake of the Woods watershed, 26,750 square miles, may be appreciated when it is understood that it is only about 5 per cent. less than the area of the Province of New Brunswick. It is greater than the combined areas of the States of New Hampshire, Massachusetts, Rhode Island, Connecticut and Delaware. Its water surface, at 3,960 square miles, is, if we except the Great Lakes system, larger than the water area of any individual State in the United States; the State of Minnesota being probably the nearest approach, with 3,824 square miles of water out of a total area for the State of 84,682 square miles.

The area of the Lake of the Woods, including Shoal Lake, with 107 square miles, is 1,485 square miles. The area of Rainy Lake is 345 square miles.

The waters of the Lake of the Woods eventually discharge into Hudson Bay. Important water power development has already taken place at the outlet of the Lake of the Woods, and also on the Winnipeg River. At the outlet there are located the plants of the Lake of the Woods Milling Company, having an installation of about 6,000 horse-power, and flour mills with a capacity of 9,000 barrels per day. The municipality of Kenora has a power plant at the outlet of the Lake of the Woods, which has an installed capacity of about 3,600 horse-power.

On the Winnipeg River at the present time, below the outlet of the Lake of the Woods, there is an installation of about 75,000 horse-power. It has been stated that there is about 290 feet of utilizable fall between the Lake of the Woods and the Winnipeg River with a potentiality under controlled outflow, exceeding 400,000 horse-power.

In order to convey some idea of the volume of water corresponding even to one foot of depth on some of these lakes, it may be stated that on the Lake of the Woods a depth of one foot is equivalent to 41.4 billion cubic feet, while the corresponding volume for one foot of depth on Rainy Lake is 9.6 billion cubic feet. Speaking in other terms, a depth of one foot on the Lake of the Woods would supply 1,313 cubic feet per second for one year, while one foot depth on Rainy Lake would supply 305 cubic feet per second for the same period.

It will be perceived, therefore, how the storing of the run-off from the Lake of the Woods watershed in Rainy Lake, Lake of the Woods and elsewhere, may be made to exert a marked beneficial influence upon water powers receiving supply from this watershed. The International Joint Commission, in making its recommendations respecting a proposed regulation of the Lake of the Woods, will consider the advantage which would result to power interests, and also take into account any disadvantages that may result to riparian owners living in the State of Minnesota or elsewhere, whose lands, bordering on the lake, may, under certain regulation of levels, be subjected to damage by flooding.

Lake Winnipeg is one of the lakes lying upon the water course which connects Lake of the Woods with Hudson Bay. As stated, comparatively few people appreciate the extent of some of these waters, and are surprised when, for example, they are informed that Lake Winnipeg has an area of some 9,400 square miles, which is about 2,000 square miles larger than the area of Lake Ontario.

Water Powers in British Columbia.—Although we have not been able to complete the report relating to the water powers of British Columbia, upon which we have been engaged, nevertheless all possible effort has been, and is being bestowed upon this work. It may not be amiss to remark that the other work, which has necessarily taken so large a part of our time, involves matters of great national importance, and which affect all the provinces of Canada.

With the continued kind co-operation of various government organizations which have hitherto greatly assisted by contributing data, it is planned that the hydrographic data shall, wherever possible, be brought up to the end of 1915. It will be appreciated, therefore, that while the British Columbia report has necessarily been delayed, it will be up to date when published, and it is believed that when the report is issued it will be of considerably more permanent reference value than could otherwise have been the case.

The Alaska Engineering Commission has completed the new water system at Anchorage, ending a water shortage which began with the freeze-up last November. During the shortage merchants and householders paid a dollar a barrel for water taken from holes chopped in the ice on Ship Creek and water peddlers sold the precious fluid at 15 cents a bucket.

OILING OF EARTH ROADS.*

By B. H. Piepmeier,
Maintenance Engineer, Illinois State Highway Department.

THE oiling of earth roads has been practised on a small scale in a number of places for the past fifteen years. California has done more of this work than any other state, primarily on account of its natural resources and climatic conditions. It has used a large amount of oil and has successfully maintained many of its roads by this method, largely on account of the oil that is available at a very low cost, and also on account of the sandy condition of the soil and the light winters that prevail.

All localities cannot expect to accomplish the same results in oiling earth roads. The black, loamy soil, the low and poorly drained conditions of many roads, together with the severe winters and springs, make it a fallacy to expect anything like a permanent road to result from the use of road oil.

It should be kept in mind that continued oiling will not make an earth road entirely satisfactory for all localities or for all conditions of traffic. The oiling of earth roads, like dragging, is a maintenance proposition. The intelligent use of oil, like the continued use of the road-drag, will maintain the earth road so that it will materially improve the present conditions existing on many of the earth roads.

The oiling of earth roads should not be practised promiscuously, but used only where the roads are suited to such work. The intelligent use of oils on many earth roads is unquestionably a justifiable expense. It is the purpose of the following to present as many facts concerning the use of oil as it is possible to secure at this time; also to describe what is shown by experience to be the best method of preparing the road and applying the oil, together with a few suggestions that may be of some assistance to the contractor or individual who has such work under consideration.

The Selection of Roads for Oiling.—Roads should not be oiled until they have a permanently established grade; that is, all hills should be cut down, hollows filled, embankments widened, and all drainage structures established. Low, flat, undrained roads should not be oiled until proper drainage has been attended to. The oiling of a mudhole will not remedy the trouble, but often aggravates it.

Roads that have a preponderance of heavy hauling should not be selected for oiling. The oiling tends to waterproof the road, but it is readily understood that continued heavy hauling, even on perfectly dry earth roads, will eventually rut and dig them out in pot holes. The mixture of oil and earth lacks stability to meet all the requirements of traffic. If something could be mixed with the oil and earth to give it stability and aid it to resist the wear of traffic, it would more nearly meet all traffic conditions.

On moderately travelled roads where there is a greater amount of pleasure travel, the oiled earth roads will give better service.

The Purpose of Oiling.—It should be kept in mind that the main purpose of oiling earth roads is to suppress the dust and aid in maintaining a smooth and waterproof surface. If it is possible to prevent dust from forming, the surface of the road will remain much smoother and there will be less mud form during rainy weather. By reducing the mud nuisance it is possible to use the road a larger portion of the year. By keeping the surface of an earth road smooth, the traffic is distributed more uniformly over the road, thereby making it wear much longer. The suppression of the dust not only makes the road wear longer, but prevents a portion of the road from blowing into the adjoining fields, washing away, etc. The oil also prevents the encroachment of weeds and sod upon the travelled portion of the highway, thus improving the appearance and producing a more thoroughly compacted road.

The suppression of dust makes an earth road more sanitary and desirable for pleasure traffic. The expense of oiling many roads is in many cases justifiable from the standpoint of the increased comfort to pleasure drivers.

A road that is oiled systematically for a series of years gradually acquires an oil-soaked crust which is more or less impervious to water. The heavy oil-soaked crust, however, will rut if the traffic is not distributed uniformly over the road and it will break through during the continued freezing and thawing of a severe winter and spring. This is particularly true if the road is used by heavy traffic. However, when such roads rut and cut through, they may be reshaped by use of the road-drag at a very slight expense.

The purpose of the oiled earth road, therefore, is not to replace what is generally recognized as a hard-surfaced road, but to keep the moderately travelled earth road in a suitable condition for ordinary traffic a larger portion of the year.

Preparation of the Earth Road.—The mistake is often made of attempting to improve a road without first grading and draining it. When a road is graded for oiling, gravelling, or any other form of surfacing, a permanent grade line should be established. Money spent in properly grading an earth road is not wasted, but has practically its full value when such a road is designated for later improvements. The great advantage of establishing a permanent grade and cross-section before the road is oiled is to utilize the oil soaked crust of earth as a foundation for later improvements, such as gravel, stone, brick or other hard road surfaces. If oil, gravel, or other surfacing material is applied to an improperly graded road, a very large portion of the material will be disturbed and practically wasted when later improvements are demanded. In other words, any money that is spent upon the public highways should be spent with a view of further improvements that will naturally be required as traffic increases.

The Road Surface Preparatory to Oiling.—As the prime objects of oiling an earth road are the suppression of the dust and the maintaining of a smooth waterproof surface, it is very important that the road surface be oiled when it is smooth, free from dust, and in a condition to absorb the oil.

Oil applied on dust will not penetrate the road surface, but will merely mix with the loose material to make an oiled-dust surface that is apt to fly readily and become a nuisance. The surface should be perfectly smooth and free from low places that will retain water. If water is allowed to stand upon an oiled earth surface, a bad mud hole will soon result. A moist subsoil preparatory to oiling is not serious, though best results may be expected when the road is reasonably dry for about two inches on the surface.

*Extracts from Bulletin No. 11, Illinois State Highway Department.

Applying Oil.—After the road has been prepared as heretofore described, the oil should be applied at the rate of one-fourth to one-half gallon per square yard of surface. If the road has never been oiled, or if more than a season has elapsed since a previous oiling, it will be found that about one-half gallon per square yard will be required. If the road or street has been oiled regularly, one-fourth to one-third gallon per square yard will usually be satisfactory. It is much better to apply a small amount of oil twice each season rather than to put on the full quantity in one application. When too much oil is applied, it is not only wasted, but is often very disagreeable to traffic.

After a road has been oiled for several years, one light application each year may be sufficient, or at least equal in results to two applications per year on a new oiled road.

The time for oiling will necessarily vary considerably, depending upon the season. Favorable times for applying the oil will be about April and September.

The uniform distribution of the material is one of the essential requirements for success. An ordinary street sprinkler or a home-made device attached to a thresher tank wagon or similar tank may be utilized for distributing the oil. An expert using such equipment can ordinarily get the required amount of oil on the road rather uniformly. Much better results, however, can be secured by the use of some specially designed apparatus made for the purpose, such as pressure distributor tank wagons.

There are a number of specially designed pressure distributing wagons on the market that vary in the price from $400 to $6,000. The horse-drawn distributors have a capacity of from 450 to 600 gallons and can be purchased at from $400 to $600. Such distributors are usually equipped with some form of heating device so that hot oil may be applied when required.

Some of the auto distributors hold 1,000 gallons and are equipped with oil heaters for heating the oil quickly; also, special oil pumps for filling the distributor and for spraying the oil upon the road in the desired quantities. Such trucks cost from $5,000 to $6,000 complete.

Shipping and Handling Oil.—Road oil is usually shipped in 8,000 or 10,000 gallon tank cars. Some companies are able to furnish 4,000 and 6,000 gallon tank cars, but such cars are very few and usually hard to get. The railroad tank cars are equipped with steam heating coils so the material may be heated in the tank by attaching a steam pipe or hose. Small quantities of oil may be purchased in molasses barrels, but when delivered in barrels there will be an additional cost of two to three cents per gallon. The tight barrels will ordinarily hold about 50 gallons. If the barrels are handled with care they can be sold at 50 to 65 cents each when empty. Heavy oil shipped in this manner is usually very difficult to remove from the barrels. In such cases the barrels are dumped into an open heating kettle and broken. After the oil is warm the staves and hoops may be removed by a large hoe or rake and used as kindling. The hot oil can be pumped from the heating kettles to the distributor and, while still hot, applied on the road.

Where there is no heating kettle on the job and there are but a few barrels of heavy oil to apply, they may be emptied direct into the distributing wagon by first placing the barrels in a very warm room or close to a fire for several hours.

Where there is but a small quantity of oil desired, say, 3,000 or 4,000 gallons, it is usually cheaper and much more economically handled if shipped in a large tank car. Freight will have to be paid on a full tank car of 8,000 or 10,000 gallons, but this will ordinarily be compensated for by the saving in barrels and in the economy effected in handling the oil on the job.

Pumping Oil.—There are a number of special oil pumps on the market that can be purchased at from $15 to $30 that will readily pump hot or cold oil. The rotary pump is the one most commonly used. It may be driven by a gasoline engine or a steam engine, in case the latter is needed at the tank car for supplying steam heat. A 1½-inch or 2-inch rotary pump will fill a 600-gallon distributor in from ten to fifteen minutes.

The ordinary water tank pump may be used for pumping cold oil. A 2-inch suction tank pump will fill a 600-gallon tank in 30 to 40 minutes. Such pumps cannot be used for hot oil, as it will soon burn out the valves.

All of the above-named pumps work best attached to the bottom of the railroad tank car by means of a hose or pipe. However, it is well to eliminate hose connections as much as possible as some oils and tars eat them out very rapidly.

A 3-inch or 4-inch lift pump may be used to an advantage in pumping oils. Such pumps are set in the tank car at the top, and one man will readily pump a 600-gallon tank in 20 minutes. This kind of pump can be purchased for $20 to $25. It has many advantages, as there is no mechanical power needed nor any pipe or hose connections.

After the pump is connected at the bottom of the tank car and everything is ready to receive the oil, the cap on the dome of the car should be unscrewed and the discharge valve opened from the inside. This valve has a stem projecting up to the dome. It is well to have a cut-off valve in the hose or pipe connection at the bottom so the tank car valve may be left open during the day that oil is being used.

If there is an elevated siding or switch eight or ten feet high at the station, the tank can be spotted thereon and the oil allowed to flow by gravity into the distributing wagon from the tap in the bottom of the tank car.

Heating Oil.—Where oil must be heated before being applied, it is often convenient to spot the car on a spur near some steam plant, such as a mill, creamery, or electric light plant. Where such arrangements can be made, a ¾-inch or 1-inch steam pipe line may be connected from the plant to the tank car. If no steam plant is accessible, an ordinary steam tractor or roller can be connected with the tank car. Where a steam connection is made for supplying the heat, from 12 to 24 hours are required to bring the oil up to 150 to 175 degrees F., which is about the maximum temperature that can be reached with the steam heat. This temperature will permit the oil to be pumped readily. Its temperature may then be increased the desired amount in the distributor.

The steam connection with the tank car is made at one of the 2-inch pipes that projects beneath the tank; the other 2-inch pipe that projects should be supplied with a valve so the amount of steam passing through the coils may be regulated.

It is advisable to have a thermometer on the job so that the temperature of the hot oil may be tested from time to time.

Some road oils have a very low flash point, and extreme care should be taken to prevent any oil from coming into contact with a flame. An analysis of an oil always shows the flash point, so it is well to keep the temperature somewhat lower to prevent burning and to be on the safe side.

The presence of a slight amount of water in heating oil will cause the oil to foam and give a great deal of trouble. Where the oil tends to foam it should be heated very slowly. In such cases every precaution should be taken to prevent accidents.

Sanding Oil Surfaces.—Better results can be secured from sanding the road slightly after either hot or cold oil has been applied. Clean, hard sand is much better on a road surface than dust or the sweepings from the road. A hot oil application should be followed with a light dressing of sand, or the traffic will likely pick up the oil and make the surface of the road very uneven. Sand may be applied at the rate of one cubic yard to each 100 to 150 square yards of road surface. It may be applied by shovels from a wagon or from a special apparatus for distributing the sand.

The application of sand gives an oiled earth surface more stability. The sand retains the oil, assists in preventing wear, and aids in keeping down the dust. The light application of sand is a justifiable expense on a majority of oiled earth roads.

Oiling Sandy Roads.—There are many sections of roads that are very sandy and have to be handled differently than the ordinary earth road. Where it is possible to mix clay or loam with the top four or five inches of sand before oiling, much better results may be expected. A suitable clay or loam can usually be secured at a reasonable distance from the sandy section. Where possible the sand and clay should be thoroughly mixed and allowed to compact under traffic before the oil is applied. The sand-clay road will permit a slightly heavier oil than the ordinary earth road.

If there is no clay or loam within reasonable distance of the sand road, it may be materially improved by mixing a heavy oil (70 to 90 per cent. asphaltic product) with four or five inches of the top layer of sand. This can best be done by applying about three-fourths gallon of oil and then covering it with about one inch of the sandy soil from the road side, then applying about one-half gallon of oil and another layer of sand. By building up successive layers of oil and sand it is possible to get from one and one-half to two gallons of oil per square yard of surface. This amount of oil mixed with four or five inches of the sandy soil will form a solid oil and sand crust that will hold up light traffic. The cost of such applications will vary from $800 to $1,500 per mile of road fifteen feet wide.

The cost of applying a four or five-inch layer of clay or loam that may be secured within one mile of the road, and mixing it with the sand, will be about the same. It is generally recognized that the mixture of sand and clay is more serviceable than the mixture of oil and sand.

The Cost of Surface Oiling.—The cost of preparing a public road for an oil treatment may vary from $100 to $2,000 per mile. However, the grading and preparation of an earth road should not be charged against the cost of oiling. The oiling or dragging of an earth road is a maintenance proposition and should be estimated separately from the building or preparing of the road. The road should be kept well shaped regardless of whether it is to be oiled or not. However, some cleaning is almost always necessary prior to the first application of oil, and this cost will vary from $25 to $50 per mile of road.

Road oil can be purchased for from three to seven cents per gallon, depending upon the quality. It may be applied on the surface of the road at the rate of one-fourth to one-half gallon per square yard. So the cost of oil alone may vary from $75 to $275 per mile of road 15 feet wide, depending upon the quality and quantity of oil applied.

The cost of applying the oil will vary, depending upon the length of haul and the kind of equipment used. This cost may be estimated at from $50 to $150 per mile of road 15 feet wide.

The above figures show the cost of oiling to vary from $150 to $475 per mile of road. With average conditions and with a medium priced oil, the average cost of oiling alone per application may be from $200 to $250 per mile of road 15 feet wide.

It is understood that the above figures are only an approximate estimate. A complete record of the cost of oiling, together with the quality and quantity of oil used each year over a period of years is not available. The above figures, however, are based on the best information available in this and other similar states.

It is predicted by some enthusiastic users that a road will not require oiling after it has been oiled for two or three years and the surface has become thoroughly saturated with the oil. The writer has visited some twenty different towns that have oiled their streets for a period of more than five years, and the present condition of such streets indicates that the oiling will have to be repeated each year indefinitely to secure the desired results. The quality or quantity of oil used in the twenty towns referred to is not known. It may be that if a high grade of asphaltic oil is used that some annual applications may be omitted after a few years of treatment. With the best oil, however, it is hardly expected that more than one year could elapse without some attention.

Some experiments have been made along the line of thoroughly saturating the top six inches of earth and then compacting it with a petrolithic roller. The saturating of the earth with the first application of two and one-half to three gallons of oil was intended to resemble somewhat the continual oiling of the surface over a period of four or five years. The experiments referred to were made in 1908 and 1909 on three different sections of road of one-half to three-fourths of a mile in length. Two of the sections were considered failures, and were within three years covered with a more desirable wearing surface. The third section still remains; however, it shows very few signs of having such a treatment. This section seems to rut in the winter and spring almost as badly as the other portion of the road; in midsummer the surface of the road pulverizes and forms a dust that flies almost the same as dust from other portions of the road.

In view of all the information that is available on oiled earth roads, indications are that the treatments must be made each year, or at least every other year, to get the desired results. On this basis, $150 to $200 per year for five to ten years may be a basis for estimating the cost of surface oiling.

Editorial

THE DEVELOPMENT OF BRITISH COLUMBIA.

Lack of space in this issue precludes more than a cursory review of Mr. Gamble's address to the members of the Canadian Society of Civil Engineers assembled in Montreal last week. It is doubtful if the Province of British Columbia has in course of preparation, or already in its archives, a more interesting historical sketch of the growth of its transportation facilities. It is unlikely that the subject has previously received more thorough consideration and study than the retiring president of the Society must have given it in the preparation of his paper. He has enriched the literature of engineering by a volume of information that will be frequently turned to in future years, not only by his associates in the profession, but by many in other walks of life. His address is a most comprehensive resumé of the development, by land and sea, of transportation in British Columbia, and of the industries encouraged and increased thereby.

Mr. Gamble "goes back to the first," and his history of early days, earlier traditions and stories or hardship and adventure are in all probability as authoritative as they are interesting. His portrayal of the white man's awakening of inland solitudes, in search of the livelihood the world owed him, when roads were trails and railways were a myth, is indicative of the optimism and perseverance that have been potent factors in the development of the West. His references to early freight rates of 15 to 18 cents per pound between Yale and Barkerville, to hay as high as $250 per ton and oats 35 cents per pound, signify that in 1867, as now, money in British Columbia persisted in having its say.

He deals with Pacific transportation in its initial stages, reviving our knowledge of the achievements of early navigators and explorers along the coast, notably Capt. Bering in 1741, Joan Perez in 1774, Capt. Jas. Cook in 1778, Capt. George Vancouver in 1792 and Alexander MacKenzie, who crossed the continent, reaching the coast in July, 1790. The establishment of trading posts by the Hudson's Bay Company, of Forts Vancouver and Victoria; the introduction into Pacific waters of the first steam vessel "Beaver" in 1836; the dangers to shipping along the treacherous coast and the establishment and growth of the present excellent system of safeguards to navigation, are subjects of extreme interest. The development within the province of the various railway systems and of coastal and oceanbound commerce is presented and, unconsciously perhaps, the manner of its presentation following a brief reference to the remarkable resources of the province is a thorough justification of the rapid expansion of facilities to trade and commerce in British Columbia.

CANADIAN WATER POWERS FOR CANADIAN NEEDS.

As one of the wealthiest countries of the world in water power resources, it is natural that Canada holds the attention of other countries as to the manner in which her water interests are investigated, controlled and utilized. We have made frequent reference in *The Canadian Engineer* to the extensive investigations of hydrographic and hydrologic nature that have been under way during recent years in practically every province. Too much attention cannot be called to the valuable work of the engineers of the Water Power Branch, Department of the Interior; the Commission of Conservation, Canada; the Hydro-Electric Power Commission of Ontario; the International Joint Commission; the Quebec Streams Commission and the Nova Scotia Water Power Commission. To a certain extent the enormous amount of water power data which these organizations have accumulated toward the economic development and proper utilization of power, is a measure of what is being done by them for the direct benefit of the nation. Study and observation are unending, however, and increase in scope and responsibility with each succeeding year. Progress is slow, as stream flow data are necessarily years in attaining dependable value. Further, there are always questions demanding prompt attention regarding the water interests of the country, requiring, perhaps, special and detailed investigations; inquiries from individuals, corporations, government departments or from the governments of other countries, often demanding an intensity of research not anticipated by the applicant.

The report of Arthur V. White, consulting engineer to the Commission of Conservation, calls our attention to the administration of some very important problems at the present time. Presented at the recent annual meeting of the Commission in Ottawa, this report, which appears in part elsewhere in this issue, brings out a phase of water-power investigation which men are often apt to forget—the safeguarding to Canada of water power resources that are Canadian. Many of the questions referred to are those relating to waters along the boundary between Canada and the United States. It is worthy of note that these questions of international importance, upon a subject that is commanding great attention in both countries, are being, one by one, settled to the general satisfaction of both. The International Joint Commission is rendering a great service to the English-speaking nations of America, a service that will not be fully appreciated in a single decade or generation.

The same applies to the other forces mentioned above. Their work is highly important, for while Mr. White points out that the time will come when Canada will have uses for her share of all boundary water powers, the time will also come when there will be use for all her water powers. To safeguard them against incompetent and improper methods of utilization should be the aim of one and all.

NIAGARA RIVER POLLUTION.

The report of the International Joint Commission concerning the pollution of boundary waters will be presented this spring, in all probability. Investigations have been under way for several years, references to which have appeared from time to time in these columns. The findings and recommendations of the Commission with respect to the Niagara River will be awaited with much interest. At Niagara Falls, Ont., for instance, there are four sewer outlets, all of them discharging into the river. They are at Bender, Seneca, Park and Orchard Streets. It is to be expected,, therefore, that a considerable readjustment of the city's disposal system may be required

It is to be expected, therefore, that a considerable re-collect the discharges from the Seneca, Park and Orchard outlets and to convey the sewage to a projected disposal plant, presumably near the Orchard Street outlet. This plant would consist of sludge beds, sedimentation tanks and chlorinating apparatus. The Bender Street outlet is too low to discharge its sewage into such an interceptor as the one suggested, and a small disposal plant may be required at its terminus. If the large intercepting sewer is recommended and constructed it will probably be a mile or more in length, with the large disposal plant in the vicinity of the Whirlpool Rapids. The interceptor will necessarily have a heavy gradient and may be not more than three feet in diameter.

Of course, no work of this nature will be undertaken before the Commission makes its report, but it is probable that the city will be required to go ahead with some such scheme as soon as the report has been made.

The Niagara River water pollution question involves also the towns of Fort Erie and Bridgeburg, on the Canadian side, as well as a number of towns and cities bordering the river in New York State. All of these municipalities will be effected by the recommendations of the Commission and in all probability adequate means to put an end to river pollution will be required in each case, similar to that described above.

ESTIMATES OF MATERIAL AND HAULAGE COSTS FOR GRAVEL ROADS.

Some useful tables relating to the matter of estimating both hauling cost and material quantities for gravel road construction appear below. The figures are derived from actual results recorded on many different projects and in different localities by the Iowa State Highway Commission. Some items of cost, as of the price of sand and gravel available, freight charges, expense of labor and teams, will vary to a certain extent in different localities, but nevertheless the tables will be of great help in striking a general average close enough for an intelligent estimate.

Table I.—Number of Linear Feet of 9-ft. Road a Load of a Given Size Should Cover for Various Loose Depths.

Weight of load Granite, lb.	Limestone, lb.	Size of load, cu. yd.	Length spread for loose depth in inches, 4-in.	5-in.	6-in.
2,800	2,500	1	12 ft.	9 ft.	7.2 ft.	6 ft.
3,500	3,125	1¼	15 ft.	11.25 ft.	9 ft.	7.5 ft.
4,200	3,750	1½	18 ft.	13.5 ft.	10.8 ft.	9 ft.
4,900	4,375	1¾	21 ft.	15.75 ft.	12.6 ft.	10.5 ft.
5,600	5,000	2	24 ft.	18 ft.	14.4 ft.	12 ft.
6,300	5,625	2¼	27 ft.	20.25 ft.	16.2 ft.	13.5 ft.
7,000	6,250	2½	30 ft.	22.5 ft.	18 ft.	15 ft.
7,700	6,875	2¾	33 ft.	24.75 ft.	19.8 ft.	16.5 ft.
8,400	7,500	3	36 ft.	27 ft.	21.6 ft.	18 ft.

Table II.—Number of Cubic Yards of Material Per Mile to Make Given Loose Depth for Various Widths of Road.

Depth of loose material in inches.	Width of surfacing 9-ft. Cu. yd.	14-ft. Cu. yd.	15-ft. Cu. yd.	16-ft. Cu. yd.	18-ft. Cu. yd.
1¼-in. (screenings	180	280	300	325	367
3-in.	440	684	733	782	880
4-in.	587	913	979	1,043	1,174
5-in.	734	1,141	1,222	1,304	1,468
6-in.	880	1,369	1,466	1,565	1,760
Sq. yds. of surface per mile	5,280	8,213	8,800	9,387	10,560

Knowing the cost of gravel in any community, the cost of the material for the road can be easily determined. The cost of hauling the gravel varies also between rather wide limits but the following may be considered as average prices where teams cost forty cents per hour and where ordinary earth roads are hauled over:

Table III.—Average Cost for Hauling Gravel Based on 40 Cents an Hour for Teams.

Length of average haul.	Cost per cu. yd.
One-quarter mile	21 cents
One-half mile	28 "
One mile	40 "
Two miles	63 "
Three miles	86 "

SYPHON LOCK ON BARGE CANAL.

THE New York State Barge Canal is an interesting piece of engineering construction with many features that are noteworthy in a comparison with the Panama Canal, the Welland Ship Canal, and others of similar rank. On it there are 440 miles of constructed canals and 350 miles of intervening natural waterways. There are 57 locks, with one flight of five locks in a distance of 1½ miles near Waterford, N.Y., the latter providing a lift of 169 feet.

The works in their original state date back to 1817, when the original Erie Canal and the old Champlain Canal were both commenced. The Oswego Canal was begun in 1825 and the original Cayuga and Seneca Canal in the following year. Enlargements have been made from time to time in these canals until in 1905 the four were incorporated into the Barge Canal system, and since that time a canalization of numerous lakes and rivers has been

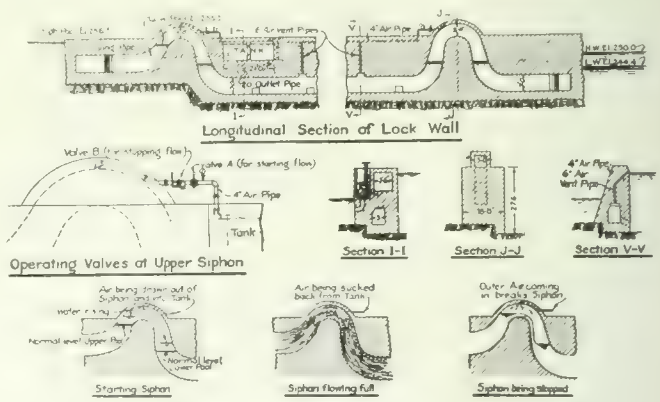


Fig. 1.—Diagram Showing Method of Operating Syphon Lock.

under way. The present design provides a channel 200 feet wide and 12 feet deep through rivers and lakes, and land lines of 75 feet bed width and 125 feet width at water line, and of 12 feet depth. There is a clearance of 15½ feet between water-line and bridges, etc.

Among the many interesting features throughout its length, there is, at Oswego, N.Y., a syphon lock of particularly notable design. It is the only lock on the system employing the syphon principle. Fig. 1, for which we are indebted to the General Electric Company, is a diagram illustrating the method of operating this syphon lock. The flow of water is started in the syphon by means of tanks. To perform an operation the tank is first filled with water, then the intake valve is closed and the outlet valve opened. There results a body of water suspended by its weight, but tending to escape into the lower pool, thus producing the necessary vacuum. On opening the air valve, air from the syphon rushes into the vacuum and water begins flowing over the crest.

COAST TO COAST

Stratford, Ont.—Mr. John Roger, county road engineer, reports a total expenditure in the county of Kent last year of $26,884.

Chatham, Ont.—The need of a county good roads system was voiced at a recent meeting of the county council and the matter received considerable discussion in view of the participation by the government in the cost of construction and maintenance under the new Highways Act, which came into force on January 18th.

Montreal, Que.—The board of control is considering a recommendation involving the construction of a barrier to prevent water from the St. Lawrence River backing up into the Little St. Pierre River, referred to in another paragraph. The proposal includes also the construction of a pump house and the total cost is placed at $120,000.

Guelph, Ont.—The annual report on county roads shows an expenditure last year, under the Highway Improvement Act, of about $25,000, of which about 25 per cent. was for bridges. The superintendent recommends the use of road oil on these county roads, as it has been found in Wellington to give good satisfaction.

Victoria, B.C.—Construction is now in progress on the Patricia Bay branch of the C.N.R. on Vancouver Island. Plans have been prepared for car ferry slips and docks at Patricia Bay for the transfer of passengers and freight from the mainland, and it is expected that a start will soon be made on the construction of terminal facilities.

Toronto, Ont.—In a recent interview Mayor Church intimated that the city would be willing to bear its share of the cost of an improved highway from Toronto to Lake Simcoe. A proposal is under way to extend the scope of the York County Highway Commission to include the roads of North York, and this main thoroughfare is receiving paramount attention.

Belleville, Ont.—According to the annual report of Mr. J. W. Evans, city engineer, 11,771 sq. ft. of sidewalk was constructed during 1915 at a cost of 35c. per sq. ft., including cost of labor, material and rent of concrete mixer. New pavements were laid on Florin Street and Victoria Avenue and about 24,000 sq. yds. of macadam were laid on various streets.

Moncton, N.B.—The Intercolonial Railway management has been working on a project involving a division between telegraph lines for railway use and commercial purposes, the desire being to obtain exclusive use of its own lines for railway business. The work has been under way for over a year, and it is expected that the new arrangement will be completed in a few weeks.

Edmonton, Alta.—The Edmonton, Dunvegan and British Columbia Railway, the head office of which is located in this city, announces that the main line reached Spirit River on January 22nd, this completing for the time being the main line programme of the company and connecting Spirit River and Edmonton by 357 miles of railway. Construction will now be proceeded with on the Grande Prairie branch, which leaves the main line near Spirit River. Steel is expected to reach Grande Prairie City in March.

Victoria, B.C.—Steel work has been completed for the new observatory which the Dominion Government is constructing on Little Saanich Mountain. Mr. C. H. Topp is in charge of the work. The building will house a 70-inch telescope, expected to be delivered not later than June, and the structure will likely be completed by that time. Water mains will be laid to the top of the mountain during the next few months and the road leading thereto will be resurfaced early in the spring.

Vancouver, B.C.—The annual report of the Vancouver and Districts Joint Sewerage Board shows an expenditure of about $787,600 on trunk sewers in Burrard Peninsula during 1915. The sewer accounts were made up of the following items: Brunette River improvement, $17,640; Balaclava trunk sewer, $129,449; Bridge Street sewer, $40,750; Central Park sewer, $565; China and Canoe Creek sewer, $69,297; China Creek extension, $187,886; Clark Drive sewer, $212,304; Clark Drive sewer, No. 2, $56,038; Hastings Park sewer, $66,987; Kaye Road sewer, $126; general plant and stores, $578.

Montreal, Que.—A report has been submitted concerning the conversion of St. Pierre River into a covered sewer. The board of control has the matter at present under consideration. This small river rises in Cote St. Luc and empties into the St. Lawrence below the city waterworks. It receives sanitary and storm sewage from the municipalities of Lachine, Ville St. Pierre, Montreal West, and Government properties, etc., and also waste water from the Lachine Canal. With the exception of about 700 ft. already covered, it is practically an open sewer. The report of the investigating commission recommends a project estimated to cost $610,000.

Ottawa, Ont.—It is expected that the International Joint Commission will conclude at least two very important investigations before the close of the present year. These are the extent and prevention of pollution of international waters and the effects of power development upon the level of the Lake of the Woods and tributary waters. Upon this latter question the commission has done an immense amount of investigatory work and is now in possession of detailed reports and of a large amount of data bearing upon the effects of lake and river levels. Meetings were held recently at Detroit and Winnipeg for the discussion of this important question.

Montreal, Que.—The following is an extract from the recent address of Mr. G. F. Benson, retiring president of the Montreal Board of Trade: "I would particularly call attention to the matter of the opposition of the Canadian Society of Civil Engineers to the present aqueduct scheme and the letter sent by our council to the Board of Commissioners. This is a question that I think needs the very careful attention of your new council, and of the members of this board. The statement is made that as a scheme for the development of power by the city, the enlargement of the aqueduct, as now proposed, is not an economic commercial proposition. It would seem to be leading to a cost of development that will greatly exceed that of any modern hydro-electric development, and the figures would indicate that it will result in a cost per horse-power to the city higher even than the cost of development by steam power, and considerably higher than the present contract price that the city is now paying for electric power. The question also arises as to whether it is in any case wise to make the city dependent upon one source of hydro-electric power, in view of the well-known troubles from frazil and backwater during the winter season, referred to in the letter addressed by your council to the Board of Commissioners."

INDEX TO VOLUME 29.

The index to Volume 29 of The Canadian Engineer (July to December, 1915), is now ready and will be mailed to any reader upon request.

PERSONAL.

D. A. GRAHAM has been appointed resident engineer at Vancouver for the Canadian Northern Pacific Railway.

C. B. GORDON, of Montreal, has been appointed deputy chairman of the Imperial Munitions Board of Canada.

J. L. COTE, M.L.A., was elected president of the Alberta Land Surveyors' Association at its recent annual meeting.

MARK WORKMAN is the new president of the Dominion Steel Corporation, in succession to Mr. J. H. Plummer.

T. J. McMULKIN has been recommended for the position of chief engineer at the city of Toronto high level pumping station.

E. H. HAMILTON has been appointed consulting metallurgist for the Consolidated Mining and Smelting Company at Trail, B.C.

WM. ALDERSON, formerly with the Timmins Co., in Northern Ontario, has been appointed superintendent of the Hollinger Gold Mines Co.

D. H. WILLIAMS has been appointed assistant general manager of the Canadian Government Railways, with headquarters at Moncton, N.B.

Capt. JOHN McHUGH, engineer in British Columbia for the Department of Naval Service, Dominion Government, is adjutant of the 104th Battalion.

C. H. FOX, formerly assistant division engineer at Winnipeg for the Canadian Pacific Railway, has been appointed resident engineer of District No. 2, Manitoba Division.

GEO. HOGARTH, B.A.Sc., O.L.S., of the engineering staff of the Department of Public Works, Ontario, has been appointed Chief Engineer of Highways, to succeed Mr. W. A. McLean, now Deputy Minister of Highways.

FRED RICKETTS has been appointed road superintendent in the municipality of Esquimalt, B.C., to succeed Mr. E. Williams, who is on active service. Mr. Ricketts was formerly in the employ of the provincial government upon similar work.

Lieut. GEO. K. WILLIAMS, B.A.Sc., formerly on the engineering staff of the University of Toronto, and a graduate of the Curtiss Aviation School, has been appointed mechanical superintendent of the Air Training School at Detling, Kent, England.

P. LECOINTE, one of the engineers in the roadways department, city of Montreal, has returned to his position after having been on active service since the beginning of the war. He was in some of the heavy fighting in Northern France, and has been the recipient of recognition for gallantry in rescuing comrades under fire.

M. O. ROBINSON, who has been manager of the Port Arthur Street Railway for the past 5½ years, has submitted his resignation. Prior to the separation of the electric railway lines of Port Arthur and Fort William, which took place in 1914, Mr. Robinson was joint manager of both. He was formerly in charge of the electrical plant of the Canadian Pacific Railway in Fort William.

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OBITUARY.

The death occurred last week at St. John, N.B., of Mr. John A. Wheatley, at the age of 78. The deceased was a prominent railway contractor in Eastern Canada. He built the northern section of the Intercolonial Railway, and also the Inverness and Richmond Railway.

The death occurred recently of Mr. Charles C. Schneider, for many years consulting engineer of the American Bridge Co. The deceased was a member of the Quebec Bridge Commission which investigated the collapse of the Quebec Bridge in 1907 at the request of the Dominion Government. In 1911 he was made a member of the Board of Engineers, under whose supervision the new Quebec Bridge is being built. Mr. Schneider was closely associated with bridge building in the United States and Canada. In the early 80's he designed the Fraser River cantilever bridge for the Canadian Pacific Railway, for which company he was afterwards for many years a consulting engineer. He was president of the American Society of Civil Engineers in 1905.

On January 24th Mr. John Alexander Hill, president of the Hill Publishing Co., New York, died suddenly, a victim of heart failure, at the age of 57. He had been an editor and a publisher for over 30 years. The success of the Hill publications bespeak his worthy achievements in engineering journalism, each being a recognized authority in its field. Of Engineering News, American Machinist, Power, Engineering and Mining Journal, and Coal Age, it may be safely said that they owe their distinction to the combination of broad and sound editorial judgment and keen business acumen possessed by the deceased.

COMING MEETINGS.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—To be held in Chicago, Ill., February 4th, 1916. Joint dinner that evening with American Electric Railway Manufacturers' Association.

NINTH CHICAGO CEMENT SHOW.—At Chicago, Ill., February 12th to 19th. R. F. Hall secretary, 208 South La Salle Street, Chicago, Ill.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Second National conference to be held at Chicago, Ill., February 15th to 18th, 1916. Secretary of the Advisory Committee, J. P. Beck, 208 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION.—Annual Convention to be held in Chicago, February 17 and 18, 1916. Secretary, E. S. Hanson, 538 S. Clark Street, Chicago, Ill.

CANADIAN LUMBERMEN'S ASSOCIATION.—At Ottawa, February 18th, 19th and 20th, 1916, annual convention. Frank Hawkins, secretary, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Meeting to be held in Cleveland, Ohio, February 21st and 22nd. Will P. Blair secretary, Brotherhood of Locomotive Engineers' Building, Cleveland, Ohio.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Thirteenth Annual Convention to be held at Pittsburgh, Pa., February 28th to March 3rd. E. L. Powers secretary, 150 Nassau Street, New York, N.Y.

CANADIAN MINING INSTITUTE.—Eighteenth annual meeting to be held at the Chateau Laurier, Ottawa, March 1, 2 and 3. Secretary, H. Mortimer-Lamb, Ritz-Carlton Hotel, Montreal.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

MAIN STREET SUBWAY, MONCTON, N.B.

NOTABLE IMPROVEMENT RECENTLY COMPLETED BY CANADIAN GOVERNMENT RAILWAYS ON THE INTERCOLONIAL RAILWAY IN THE CITY OF MONCTON—NOTES ON ITS DESIGN AND CONSTRUCTION.

THE Canadian Government Railways have recently completed the construction of a subway to carry the tracks of the Intercolonial Railway over Main Street in Moncton, N.B. This crossing was previously of a dangerous character owing to the busy traffic on both railway and street. The intersection had become a particularly annoying one in recent years, so, in the summer of 1914 the Government Railways decided to eliminate the level crossing by constructing, with the consent of the ratepayers, a steel and concrete subway. The improvement is an important one for the city of Moncton, affecting not only Main Street, but Archibald and Foundry Streets, as the accompanying layout diagram illustrates.

Preliminary operations were commenced in December, 1914. They comprised a considerable amount of excavation and a diversion of the water, sewerage and gas mains. This work was carried on during winter months and dynamite was sometimes resorted to by the contractors in excavating through some three feet of frost. Excavation was completed early in March, 1915. Directly in the centre the ground was excavated to a depth of 13 feet, while the tracks were raised some 5 feet and graded accordingly on both ends. The excavated material, amounting to about 15,000 cubic yards, was removed with a 28-ton Marion revolving shovel and transported from the site in 6-yard dump cars drawn by a Dinkey engine.

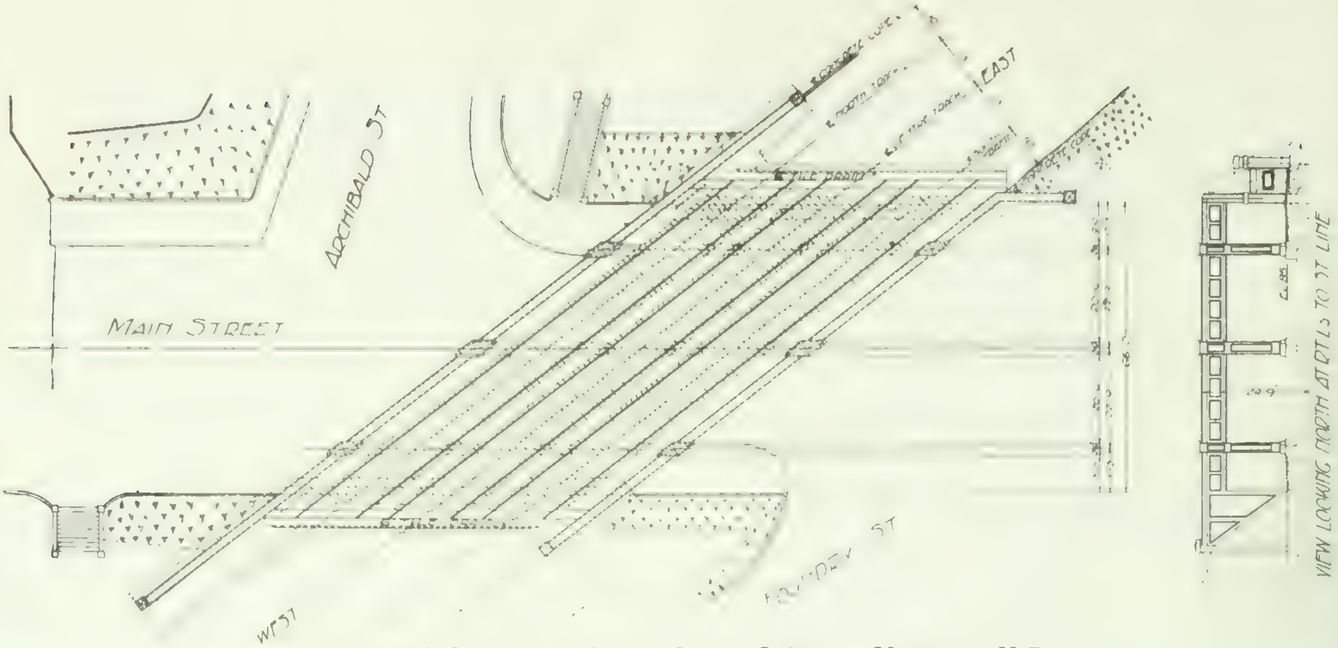
View from Archibald Street of Main Street Subway, Moncton, N.B.

A temporary trestle was erected on the north side of Main Street and was in use for a period of about six months or during regular construction operations, and little inconvenience was caused to pedestrian traffic. Vehicular traffic was diverted to other convenient streets.

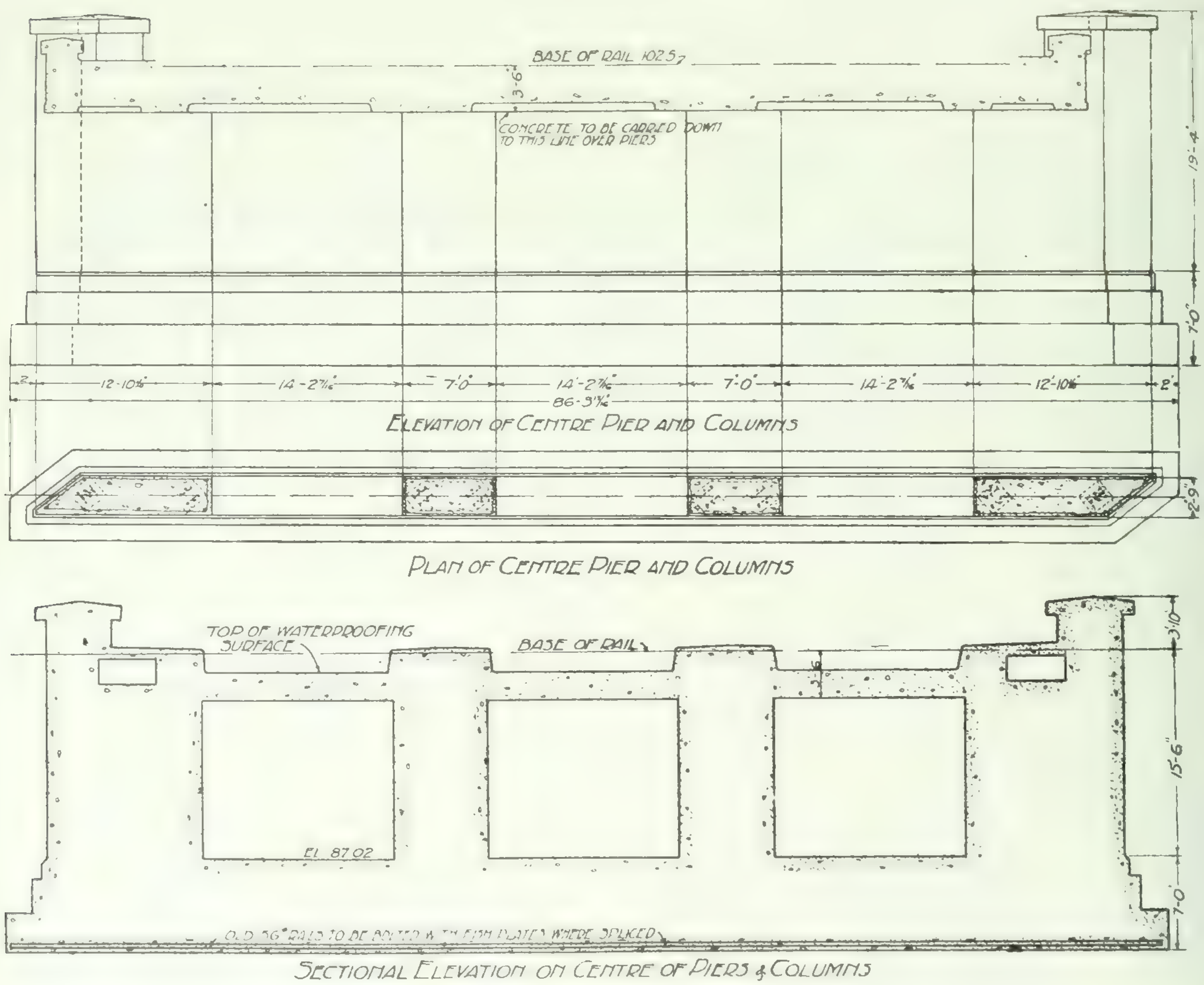
The structure is of steel encased in concrete and with reinforced concrete abutments. As illustrated by the views from points on Main and Archibald Streets, it presents a well-balanced appearance, the design being artistic, yet practical, and the finished work giving a pleasing effect. The subway is 80 feet in width and is spanned by a bridge 115 feet in length. The latter has a reinforced concrete waterproof floor and carries three tracks and two walkways for railway employees. Both upper and lower floors are provided with adequate drainage facilities. The general features of the structure are indicated in the drawings shown herewith.

The subway is lighted on the exterior with cluster lights, as shown, and underneath with ceiling lights, which are located in the openings of the piers.

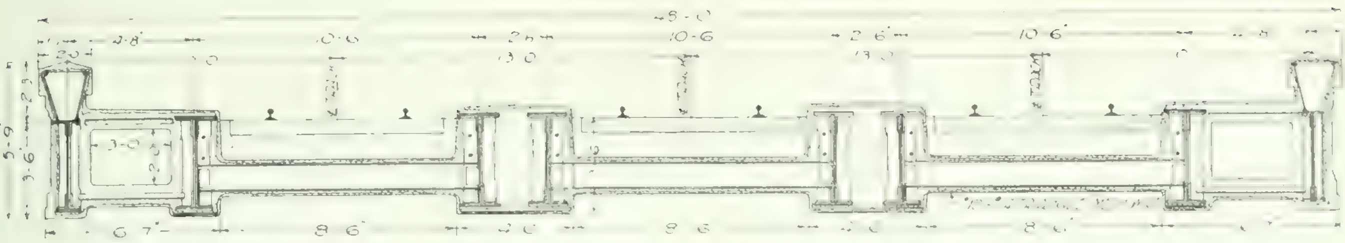
The improvement included laying wood block paving for a short distance on either side of the subway. The foundation for this work was prepared first by a six-inch layer of cinders rolled with a 16-ton roller. Over this was spread concrete to the thickness of 6 inches, which was covered by a finished paving composed of 3-inch creosoted



General Layout of Main Street Subway, Moncton, N.B.



Column Details of Subway.



Cross-section Through Span, Showing Arrangement of Concrete on Girders.

wood blocks, set on sand and the space between the blocks filled with hot pitch.

Apart from paving, the portions of the streets affected by the crossing elimination have been suitably banked and sodded, the grass-finished terraces sloping towards the subway adding considerably to its artistic appearance.

Concrete work began on May 27th, 1915, and was completed November 20th. Some 27 cars of cement, 175 cars of gravel, 25 cars and 10 scow loads of sand were used. Three mixers were employed. The exposed surfaces of the concrete are to be tool finished, this operation having been partly completed when the accompanying photographs were taken.

As shown in the illustrations, street railway tracks are laid on both roadways, through the subway. The track west of it has a 7 per cent. grade, and a 5 per cent. grade eastwards. The Archibald Street approach has also a 7 per cent. grade.

Mr. F. P. Gutelius is general manager of the Canadian Government Railways, and Mr. C. B. Brown chief engineer. Mr. W. A. Duff, engineer of bridges, designed the subway. Messrs. Soper and McDougall, of Ottawa, were the general contractors, Mr. A. L. McDougall being superintendent of the work. Messrs. Rhodes, Curry Co., Limited, Amherst, N.S., were contractors for the steel work. Mr. G. C. Torrens was engineer-in-charge and Mr. F. Stratton chief inspector for the railway.

Subway at Moncton, N.B., Looking Easterly Along Main Street.

THE PRESENT STAGE OF THE PACIFIC GREAT EASTERN RAILWAY CONSTRUCTION.

The Pacific Great Eastern Railway is now operating as far as Clinton, a distance of 180 miles from Squamish, the tidewater port of Howe Sound. All the remainder of the line to Prince George has been graded with the exception of 30 miles at Horse Lake, in Northern Cariboo. What still remains to be done to make a completed railway is to build bridges and lay steel from Clinton to the junction with the Grand Trunk Pacific at Prince George. Approximately $22,500,000 has already been expended on the line, according to Hon. Lorne Campbell, Minister of Mines, B.C., who is chairman of a government committee reporting on uncompleted railway projects, and the company, owing to its inability to market its bonds, is now out of construction funds. It has been estimated that it will take $6,500,000 to finish the work and secure the completion of a real link of communication with the rich interior of the province.

Mr. Campbell states that the Pacific Great Eastern, in the first instance, was assisted by the government, by way of a guarantee of bonds to the extent of $35,000 per mile. Early sales of bonds were very successfully made, and the company had every expectation of being able to finance the undertaking without difficulty. But the war intervened and calculations were upset. Issues of all kinds were barred from London, and the only place where money can be obtained is New York, and there is now a very poor market.

The authorized extension of the Pacific Great Eastern into the Peace River country is on a slightly different basis from the portion on the line from Prince George to Squamish. The line was surveyed to the eastern boundary of British Columbia, but no market could be found for the securities, even though guaranteed by the government. That part of the line is, therefore, untouched, and the situation precisely the same as if the contract had never been entered into. Construction work by the company is altogether contingent on the marketing of the bonds at reasonable figures.

"If the government," said Mr. Campbell, "should at present desire to proceed with the Peace River connection it would have to supplement its original guarantee by an interim loan, or otherwise assist the company with funds that would, for the time being, take the place of the proceeds expected from the sale of the bonds. Thus, so long as conditions continue as they are, the rapidly growing traffic of the Peace River country will be diverted to Edmonton and the east, instead of following the route to tidewater on the British Columbia coast."

The Minister of Mines, speaking of the immigration flood which he believed would follow the war, stated that he could conceive of nothing better calculated to meet the situation than the opening of the rich interior of the country through the speedy completion of the Pacific Great Eastern Railway.

ESSENTIAL PHYSICAL PROPERTIES OF SAND, GRAVEL, SLAG AND BROKEN STONE FOR USE IN BITUMINOUS PAVEMENTS.*

By Francis P. Smith, Ph.B., M.A.S.C.E.

IN discussing the various physical properties of mineral aggregates it must be borne in mind that it is impossible to fix universally applicable definite values for them, as these will vary with the type of pavement and the kind and density of the traffic to which it is subjected. In order to understand fully the extent to which these considerations affect the selection of the mineral aggregate to be employed and modify any standards set for their essential physical properties, it is necessary to have clearly in mind the different types of bituminous pavement and of traffic and to discuss briefly a few points illustrative of their mutual relationship.

The types of pavement considered in this connection are: (1) Sheet asphalt, binder, surface; (2) bituminous concrete; (3) bituminous macadam; (4) asphalt block; (5) oiled macadam; (6) gravel.

Broken stone or gravel is used in all of these types, but in the case of sheet asphalt their use is restricted to the binder course in which they are not directly subjected to wear. In all the other types the broken stone or gravel forms part of the wearing surface. Obviously in the binder course neither of them would be required to possess the same degree of wear-resisting quality as when used in the surface.

The kind of traffic may be classified as: Iron-tired, chiefly horse-drawn; rubber-tired, chiefly self-propelled; mixed, both horse-drawn and self-propelled; and without entering into a detailed segregation, the traffic itself may be classified as: Light, medium, heavy.

Stone and gravel which would crush under heavily loaded iron-tired traffic would carry the same weight without fracture if rubber tires were used. The same distinction would apply in the case of heavy traffic as compared with light traffic.

A certain amount of crushing, thus increasing the proportion of fine material in the mineral aggregate, is desirable in certain types of pavement, such as tarred slag, when sufficient quantities of a soft bituminous binder are used with it which will readily cost the freshly fractured surfaces at ordinary atmospheric temperatures.

Where the bitumen is present in insufficient quantity or where it requires temperatures higher than atmospheric ones to make it adhere satisfactorily to the particles, the reverse is true.

Having before us this very wide range of conditions which must be met, we next come to a consideration of the physical properties themselves which are ordinarily regarded as essential. These are: Shape, character of surface, wear-resisting quality, size, cleanliness.

Shape.—Owing to the fact that all bituminous cements soften materially under heat and therefore lack stability in hot weather, it is desirable and necessary to obtain as great a degree of stability as possible in the particles whether they be coarse or fine. Gravel, with its rounded particles, has much less stability than broken stone. For this reason it is often passed through the crusher before using it. Stone which is crushed so that the particles are chiefly cubical in shape is to be preferred to stone that is crushed so that slivers predominate. These slivers do not compress as easily as do cubical particles to form a compact mass with a minimum of voids and are much more liable to fracture under the stress and weight of traffic. When the particles are small, their lack of weight and size render them more subject to displacement and angularity and consequent interlocking of the particles is very essential. At first sight this would appear to be much more important in the case of sand than in the case of stone. The larger the particle, however, the greater the leverage with which it may act under a force tending to displacement, hence there is not so great a difference between the relative importance of angularity in sand and stone. In fact, in certain cases it is more important with stone than with sand. In the binder course in sheet asphalt pavements, which is intended to increase the stability of the sand wearing surface and key it to the concrete and retard its movement upon the surface of the concrete, sharpness of stone is essential. For this reason gravel makes a very inferior binder and should not be used where it is possible to obtain stone. When used, it should be cracked by passing it through a crusher. Not only do rounded particles move on each other with greater ease than angular particles, but in masses they have fewer points of contact.

Character of Stone.—As our consideration of the materials under discussion is limited to their employment in bituminous pavements, it is necessary for us to consider the surfaces of them chiefly in connection with their ability to receive and retain a coating of sufficient thickness of the bituminous cementing material. Certain types of surfaces are much more desirable from this standpoint than are others. Broadly speaking, a rough, pitted and somewhat absorbent surface is the best. Smooth, glossy surfaces do not readily retain a thick coating of bitumen and require a relatively high heat to insure properly coating them. At a high heat the bitumen becomes very liquid and readily runs off of them, which results in a coating of undesirable thinness. Even when the temperature at which they are coated is no higher than that employed with rough surfaces, their smoothness permits the bitumen to drain off more readily. This is particularly the case with flint particles and sands containing them, when coated with bitumen and examined under a glass, invariably show the minimum thickness of coating on the flint particles sharply contrasting with the surrounding rougher surfaced quartz particles which have retained a coating of normal thickness. As compared with a non-absorbent surface, an absorbent one *per se* is to be desired. Unfortunately, most particles which have absorbent surfaces are lacking in resistance to wear and therefore, notwithstanding their superiority from the standpoint of coating them with bitumen, are not suitable for heavy traffic, more especially of the iron-tired variety. Where the bituminous cement used is lacking in cementing value an absorbent surface is especially necessary.

The speaker knows of a number of roads in which distinctly inferior bituminous cement was used which gave excellent satisfaction under medium and light traffic due to the fact that the mineral aggregate was a porous limestone. The same bituminous cement with hard non-absorbent rock failed utterly when used in similar types of construction on roads carrying an equivalent traffic.

The outer surface of the particles must be firmly adherent to and form a permanent part of the particles themselves and must show no tendency to scale off when heated. Certain sands, upon heating, appear to form loosely adherent scales upon the surface of their particles which are not removed by attrition in the mixer but which, under the stress of traffic and atmospheric changes in temperature, become loose and detach themselves, carrying the coating of bitumen with them. Pavements laid with this type of sand have been known to disintegrate

*A paper read recently before the Graduate Section of the Highway Engineering Course at Columbia University.

from this cause alone within a few weeks from the time they were laid. Gravel, freshly broken slag and stone are ordinarily free from this defect. Slag which is glassy does not coat as well with bitumen as do the more basic slags.

Wear-resisting Quality.—This, while a very important property, is perhaps more of a variable one than any of the other qualities mentioned. The degree required depends upon the kind and density of the traffic, the size of the particles, the type of pavement and the hardness of the wearing surface considered as a whole. We have already noted that an iron-tired traffic exerts a greater crushing action than a traffic that is carried on rubber tires and it goes without saying that a dense traffic is more severe in this respect than a light traffic. Up to a certain point, the larger the particle, the greater the liability to fracture and where the traffic is very heavy, aggregates consisting of relatively large particles will not give satisfactory service even though composed of the hardest known rocks, unless the particles are sufficiently massive to resist fracture, as, for instance, ordinary paving setts, which are, of course, outside the limit of bituminous pavements. In other words, broken stone or gravel of from ½ to 1½ inches in size requires more careful scrutiny as to its resistance to fracture than do sand or paving blocks. Resistance to fracture is, of course, only one of the elements going to make up wear-resisting quality. Hardness is also a requisite, although a very hard and at the same time brittle material would not be suitable for use in bituminous pavements. A pavement which is soft and yielding as a mass does not require as hard and tough a mineral aggregate as does a more unyielding pavement. The shock or impact, as well as the grinding action of traffic, is minimized by the plasticity of the pavement in the same way that it is difficult to break a rock of relatively small size when supported on a yielding bed. When the particles are heavily coated with a relatively fluid bitumen, fractures of the particles are to a certain extent self-healing. In this type of pavement, therefore, somewhat softer rock may be safely used than in those types in which the bitumen is harder and the coating on the particles thinner.

Size.—This property has to do not only with the actual size of any one particle or set of particles, but also embraces the question of the relative size of the different particles composing the aggregate as a whole, which constitutes what is frequently referred to as the grading of the mass. As previously mentioned, large sized aggregates will not carry excessively heavy traffic and this not only refers to the difference between broken stone and sand, but to different varieties of sand as well. For ordinarily dense and heavy traffic, sheet asphalt pavements carry from 2 to 10% of sand particles which will just pass a 10-mesh sieve and are approximately 0.027 of an inch in diameter. Where the traffic is exceptionally heavy, particles of this size are liable to fracture and the maximum size must be still further reduced. In certain heavily travelled streets in Glasgow, Scotland, the speaker was forced to limit the maximum size of the sand particles to those which would pass a 30-mesh sieve. Such particles would have a diameter of approximately 0.01375 of an inch. The ability of a very fine and comparatively soft aggregate to sustain the heaviest known traffic is perhaps best exemplified by the French rock asphalt pavements. These pavements are largely composed of particles which will pass a 200-mesh sieve and have an approximate diameter of 0.00235 of an inch. The particles themselves are composed of a soft limestone thus showing the possibility of using relatively soft materials when they are in a fine state of division. The bitumen with which they are coated is relatively quite soft, which again accentuates a point previously referred to; *viz.*, the possibility of using soft materials with a fluid bitumen. The relative size of the different particles or the grading of the mineral aggregate is perhaps one of the most important considerations in the construction of a bituminous pavement. On it much of the success of the pavement depends. The maximum size of the particles and the allowable proportion of maximum sized particles is, as we have seen, dependent upon the traffic. If all the particles were of practically the same size, they would touch at only a few points of contact and the pavement would have a large percentage of relatively large voids. The weakness of the bond due to the few points of contact would make it pick up or ravel under traffic and the relatively large sized voids would permit the bitumen to drain off the hot aggregate during transit to the street or road, leaving a very thin coating on the particles and thus still further weakening the bond. Any considerable excess of bitumen in the mixture would result in the formation of "fat spots" in the pavement where the excess of bitumen had collected. If the temperature at which the mixing took place was lowered, there would be danger of not properly coating the particles and in cold weather a mixture of this type would be very difficult to rake and would break up under the roller, and it would be impossible to compress it into a compact mass. It is, therefore, essential to fill up these large sized voids with smaller particles. If all of these smaller particles were exceedingly minute, they would present a very large surface area to be covered by bitumen, and would, therefore, increase the cost of the pavement. The mass formed by them would be very plastic owing to the relatively high percentage of bitumen necessitated by the conditions of mixing, and would not key the larger particles together as firmly as if the filling mass were partly composed of the largest sized particles which would go into the voids between the large aggregate. The French rock asphalt, while composed almost entirely of very small particles, has a very high degree of stability and contains a relatively low percentage of bitumen by which it has been impregnated by natural processes in which time was not a factor. The average time of mixing a batch of bituminous pavement does not exceed one minute and the consistency of the bitumen is usually much harder than that found in the French rock. It is therefore impossible, under working conditions, to satisfactorily coat a fine aggregate with as small a percentage of bitumen as is found in the French rock and the stability of the mixture is lessened by this relative excess of bitumen. It is, therefore, essential to first fill the voids between the maximum sized particles with the largest sized pieces that will go in them. The remaining voids should then be similarly filled and so on down to those voids which can only be filled by particles passing a 200-mesh sieve. The proportion of these particles will not ordinarily exceed 15% in a sheet asphalt pavement, the governing factor being the production of a dense surface which will not be water-absorbent and having as large a proportion of mineral aggregate as possible. Closeness of grain could, of course, be obtained by an excess of bitumen, but this would increase expense and reduce stability. Where the maximum size of the particles approaches one inch the percentage of 200-mesh material in the pavement is, of course, much lower than in sheet asphalt pavements and varies from 3 to 5% on the average. Particles of 200-mesh sand are not desirable in a pavement owing to the fact that they detract from its stability and if present to any considerable extent, tend to make the mixture mushy. All, or the greater portion of, the 200-mesh material should be finely ground limestone or Portland cement, as this materially adds to the the stability of the pavement.

In order to comprehend how the increase in fine material adds to the surface area to be covered with bitumen, let us consider a one-inch cube of stone. It has six sides, each 1 sq. in. in area, or a total of 6 sq. ins. Let us now saw it through the middle. It has now the original six sides and two more, each of 1 sq. in. in area, or 8 sq. ins. in all. Keeping the pieces together and cutting it again in a plane at right angles to the first cut we add two more square inches in surface area, making 10 sq. ins. in all, although the volume of the mass has not been increased.

In certain of the tarred slag pavements in which a very soft tar is used, the pavement as laid is very deficient in fine particles. The top layers of slag are expected and do crush to a very considerable extent under traffic and the fine particles thus produced are coated by the soft tar at atmospheric temperatures and are incorporated into the pavement; thus, in a short time forming a dense compact mass which, under light and medium traffic, gives excellent satisfaction. A large quantity of this pavement is laid on country or suburban roads in England and costs about half a crown (62½ cts.) per square yard. With any other type of bitumen which was not very fluid and which would not coat particles satisfactorily at atmospheric temperatures, such a pavement would be a very dangerous type to lay. The sharp particles of slag key very firmly together and once the sufficient amount of fine material is produced by traffic crushing, the pavement is a remarkably stable one and sufficiently close grained to keep the water out. As illustrating the grading in various kinds of pavement, the following typical examples are given:—

	Sheet Asphalt. Heavy Traffic. %	Sheet Asphalt. Light Traffic. %	Topeka. %	Bituminous Concrete. Hot Mixture. %	Bituminous Concrete. Cold Mixture.
Bitumen	11.0	10.5	8.5	7.0	6.5
Passing 200 mesh..	14.0	10.5	8.5	5.0	4.5
" 100 " ..	14.0	10.0	6.0	4.0	1.5
" 80 " ..	13.0	10.0	6.0	2.0	1.5
" 50 " ..	19.0	14.0	6.0	5.0	1.5
" 40 " ..	11.0	14.0	10.0	4.0	1.5
" 30 " ..	10.0	13.0	10.0	4.0	1.5
" 20 " ..	5.0	10.0	9.0	3.0	3.0
" 10 " ..	3.0	8.0	6.0	5.0	5.5
" 8 " ..	...	...	6.0	3.0	5.0
" 4 "	..	...	14.0	7.0	8.0
" 2 "	.	...	10.0	20.0	40.0
" ¾" "	.	...	....	14.0	11.0
" 1" " ..	...	...	....	12.0	9.0
" 1½" " ..	...	...	....	5.0	...
	100.0	100.0	100.0	100.0	100.0

In addition to the increase in stability due to the proper grading or sizing of the different articles and the consequent increase in density, a reduction in the size of voids is obtained. The latter feature is essential in that it keeps the water out of the pavement. Any bituminous pavement which is sufficiently porous to permit the water to enter it and be retained therein will soon disintegrate due to the loosening of the bond between the bitumen and the particles by the action of the water. Another consideration involved in the selection of the size of the mineral aggregate is the kind of surface desired on the finished pavement. The larger the aggregate the rougher and less slippery the surface. We have already seen, however, that with a very heavy traffic, large sized aggregates are not permissible. A smooth, fine-grained pavement composed of small particles, if properly designed, is suitable for all kinds of traffic but is undoubtedly more slippery than the coarser type.

Cleanliness.—Many sands and gravels have finely divided clayey material adhering to their larger particles. Such sands and gravels are unsuitable for use in bituminous pavements unless first washed. When passed through the heating drum or dryer, this clayey deposit becomes burned on to the surface of the grains by the heat to which it is subjected to such an extent that it is not removed by attrition in the mixer. It thus prevents the bitumen from coming into contact with the actual and permanent surface of the larger grains and subsequently breaks loose from them, carrying the bitumen with it. This results in the disintegration of the pavement as the uncoated particles soon wear or wash away, leaving depressions in which water will accumulate. Clayey material, unless finely pulverized after drying, is always objectionable. Even if it does not adhere to the grains, it bakes into balls in the dryer, only the outside of which can be coated with bitumen and these balls readily break up under traffic, leaving similar depressions to those above described. A pat of surface mixture made of clayey sand will, when broken open, invariably show these clay balls with uncoated powdery centres. In a recent type of bituminous pavement the manufacturing process involves the pulverization of the mineral aggregate after it has been dried and heated. Under such conditions clay makes a most excellent paving material, as it readily absorbs the asphalt and clings tenaciously to it, the bond between them being much stronger than in the case of sand, gravel or crushed rock. Under certain special conditions, therefore, that which is ordinarily to be avoided becomes highly desirable. Crushed stone or gravel from which the dust has not been removed and which has been allowed to stand exposed to the weather will almost invariably have the larger particles partly covered with strongly adherent stone dust which has formed a sort of cement by the action of water, and material of this kind should be rejected. For this reason, most specifications call for freshly crushed stone. This is especially important in the case of stone for use in asphalt blocks. The bituminous cement largely used in the manufacture of these blocks has a high melting point and is therefore not very fluid at the temperatures employed during mixing. Under such conditions, the use of a clean stone is absolutely essential. A very fluid bitumen might perhaps be sufficiently absorbed by these fine particles to permit of its reaching the actual surface of the stone through capillary action during the mixing process and might even be relied on to subsequently coat the larger particles at atmospheric temperatures after their imperfectly adhering mineral coating had become detached in the pavement by the stress of traffic. With a bitumen of high melting point and low ductility this would, however, never take place.

At first sight it might appear that the addition of 5 to 20% of finely ground Portland cement or lime dust to the mixture would produce the very conditions of finely divided particles adhering to the larger ones that have just been classified as extremely undesirable. It must be remembered, however, that this filler is added to the mixture *after* it has passed through the heating drums and is in itself dry and there is, therefore, no chance of its becoming baked on or firmly attached to the larger particles.

In the practice of his profession, the engineer is frequently confronted with the problem of selecting not that which is economically the best in the long run, but what is the best that can be done with the appropriation that has been put at his disposal, and the speaker hopes that the foregoing discussion will in some degree aid him in this most difficult task. If the sand is unsuitable or very expensive to obtain and the traffic is not very heavy, and a satisfactory supply of rock at a reasonable price is at hand, rock is obviously the material to use. If the rock is unsuitable or dear and the sand good and cheap, a sand

asphalt mixture will carry practically every kind of traffic. With a cheap local supply of bitumen of fair but somewhat inferior quality, an absorbent limestone will often make a very satisfactory pavement for carrying light traffic. Sands which are lacking in fine or coarse particles can frequently be brought up to the proper standard of grading by the addition of fine or coarse unweathered crusher screenings.

Summary.—Sand should be clean grained, hard and moderately sharp. The grains should be chiefly quartz and should have rough pitted surfaces. If necessary, as will usually be the case, the proper mesh composition or grading must be obtained by the mixing of several sands or possibly by the addition of unweathered crusher screenings. In the ordinary type of sheet asphalt pavement the presence of clay is undesirable, either as a coating to the grains or disseminated throughout the mass. For medium and heavy traffic pavements all particles retained on a 10-mesh screen should be discarded. For light traffic three to five per cent. of 8-mesh particles can be incorporated in the pavement with advantage. Sands containing a large percentage of flinty grains should be avoided.

Gravel should be clean grained, hard and free from adhering clayey particles. It is lacking in stability owing to the roundness of its particles and is usually considerably improved by passing it through a crusher. Gravel with a rough pitted surface is to be preferred and gravel containing a large percentage of flinty particles is to be avoided. Unsuitable for the construction of pavements carrying heavy traffic and inferior in all respects to crushed stone.

Slag. Hard, dense basic slag is to be preferred. Should be stable when exposed to weather and not show any tendency to slack or disintegrate. Only suitable for light traffic and should preferably be coated with a very fluid bitumen.

Broken Stone. Should be freshly crushed, preferably in cubical shaped particles. Size and hardness required depends upon the traffic which the pavement is to carry. Dense, hard limestone will carry medium and light traffic satisfactorily. When the traffic, though light in volume, is composed of heavy iron-tired units, a dense, hard trap is required. Trap is now comonly used for asphalt block manufacture, although in the past a large number of asphalt blocks made from limestone gave excellent service under light traffic. Granite is not usually satisfactory, as it is too coarse and uneven in texture and much of it is friable and it is liable to shatter in crushing. Mesh composition just as important as with sand. Not suitable for use in pavements carrying very heavy traffic.

RAILROAD EARNINGS.

The following is a record of the transcontinental railroads' gross earnings for the first three weeks of January:—

Canadian Pacific Railway.

	1916.	1915.	
January 7	.... $1,874,000	$1,316,000	+ $558,000
January 14	 1,863,000	1,321,000	+ 542,000
January 21	 1,910,000	1,391,000	+ 519,000

Grand Trunk Railway.

January 7	.... $ 880,702	$ 753,522	+ $137,180
January 14	 966,301	779,745	+ 186,556
January 21	 980,914	795,830	+ 185,084

Canadian Northern Railway.

January 7	.... $ 541,100	$ 315,700	+ $225,400
January 14	469,300	349,300	+ 120,000
January 21	504,000	322,600	+ 181,400

THE ACTIVATED SLUDGE PROCESS OF SEWAGE TREATMENT.

In *The Canadian Engineer* for December 2nd, 1915, there appears an abstract of an International Engineering Congress paper on "Disposal of Suspended Matter in Sewage," contributed by Mr. Rudolf Hering, D.Sc., of New York. We are now able to present a very able discussion of this paper, submitted by Dr. Gilbert J. Fowler, of Manchester, who replies to some of Mr. Hering's comments in an interesting way that will be appreciated by many of our readers who have been closely following our articles and references to the activated sludge process of sewage treatment.

Dr. Fowler states that experience at the Withington sewage works of the Manchester corporation bears out much of what Dr. Hering has stated in regard to the operation of the Imhoff tank. The necessity for periodically stirring the scum is a somewhat serious matter; if mechanical agitation is to be used it will introduce complication and cost. The statement that exposure to the air tends to increase putrefaction, appears *a priori* open to question, and he would like rigid scientific evidence on the point. His experience with the Imhoff tank has confirmed him in his belief that the final solution of the sewage problem is not to be found in processes involving anaerobic action but on the lines of aeration, putrefaction being avoided at every point.

The history of the development of what has come to be known as the "activated sludge process" is carefully given in the first paper by Messrs. Ardern and Lockett (Jour. Soc. Chem. Ind., No. 10, Vol. xxxiii., May 30th, 1914.)

The articles which have recently appeared in American technical journals, describing experimental work at various centres, are clear evidence that the work of the English investigators marks an advance on anything previously accomplished.

It is a matter for satisfaction that the interchange of scientific work on both sides of the Atlantic should eventuate in progress for the general good.

The question of priority where so many workers are involved is of small importance in itself. When, however, statements are made by Dr. Hering and others which obscure the scientific understanding of the process, it is important that they should be corrected.

It is quite true that he (Dr. Fowler) was much impressed by Mr. Clark's work at Lawrence, and to the Massachusetts workers is due the idea of building up by prolonged aeration of successive quantities of sewage a growth which would rapidly purify sewage in the presence of air. But the question of expensive surfaces, difficult to construct and handle, still remained and because of this the possibilities of the process were not favorably considered by the Metropolitan Sewerage Commission with whose president the matter was carefully discussed. The writer, therefore, returned from New York considering the problem of how to bring about purification in open tanks with, at any rate, the least possible addition of costly chemical precipitants. The idea of adherent growths was therefore abandoned in favor of some process of bacterial or enzymic activity, a line of thought which had previously been present in the mind through a suggestion by Dr. Maclean Wilson (Jour. Soc. Chem. Ind., No. 23, Vol. xxx., p. 1348, 1911.) From this line of thought was developed what has come to be known as the "M7" process, which was described in a paper by the writer and E. M. Mumford at the Congress of the Royal Sanitary Institute at Exeter in July, 1913.

By this method a bacterium was made use of, discovered in colliery waters, termed "M7," which had the property of precipitating hydrated oxide of iron from solutions containing salts of iron, together with organic matter.

Sewage from which the grosser solids had been removed by sedimentation was treated with a small quantity of iron salt and inoculated with the organism referred to, and aerated for several hours. Perfect clarification took place, and a deposit containing a very high percentage of nitrogen (as much as 10 per cent.) was formed.

The effluent from this process could be nitrified at very high rates on percolating filters.

Inasmuch as preliminary settlement of the sewage was called for by this process, with production of ordinary sludge, and as the effluent still required final treatment on filters for complete oxidation, the method, although having many advantages, did not completely realize the object of the researches.

In the development of the field experiments in connection with this process, valuable practical experience on the economical application of air was, however, gained. Contemporaneously with this work, experiments were being carried on at Davyhulme, at the writer's suggestion, on the continuous aeration of successive quantities of sewage, as in the Massachusetts work, and these experiments ultimated in the activated sludge process described in the various papers of Messrs. Ardern and Lockett.

It is now possible to correlate the various results which have been obtained and to get some steps nearer to a proper understanding of the nature of the process. The writer's present idea is that it can be referred entirely to bacterial activity. It was distinctly stated, in the first paper by Messrs. Ardern and Lockett that their sludge did not contain any algal growths; the process thus differs essentially from that which was in operation at Lawrence at the time of the author's visit and which was subsequently described in the annual report of the Massachusetts State Board of Health for 1913, p. 289 and seq.

It would appear, therefore, that the activated sludge process consists broadly of three operations: a clotting or clarifying action, a rapid carbon oxidation process, and finally, nitrification. It is probable that the first process is, to some extent, the result of the activity similar in character to "M7" organisms which was definitely shown to depend on enzymic action whereby traces of iron appeared to start the flocculation of the whole sewage. The "M7" bacillus is probably fairly ubiquitous, as it has been found that sewage containing iron and a certain amount of partially activated sludge but in which clarification has not been effected, can be made to clarify almost at once by the addition of a small quantity of properly activated sludge. Simultaneously with clarification, the organic matters in solution follow the usual course of oxidation, which takes place rapidly owing to the enormously extended area of bacterial activity. In the writer's opinion, the outstanding advantage of the process lies in the fact that the sewage is really clarified and the process of clarification results in the precipitation of the emulsified nitrogenous matter in the sewage. This has hitherto not been arrested in any process of tank treatment, with the possible exception of certain precipitation processes which involve the addition of large quantities of costly and inert chemicals. Experiment has shown that bacterially precipitated sludge is quite extraordinarily active as a manure and there seems every reason to believe that an important step has been taken in the ultimate aim of economic sewage disposal, *viz.*, the return of nitrogen to the land.

A great deal of research remains to be done on the conditions of activity of the sludge, both as an agent in sewage purification and as a manure, but advance is only possible by patient and exact biochemical investigation, and it is of the utmost importance that unfounded assumptions and short-cuts of all kinds, which have been responsible for so much waste of public money on sewage treatment plants in the past, should be avoided.

It cannot be too strongly emphasized that the proper treatment of sewage is a matter, in the first place, for the scientific specialist; when he has worked out the governing facts of the situation, it remains for the engineer economically to construct the plant which fulfils these conditions.

In the present case, the engineering problem is a comparatively simple one; it is merely to keep the activated sludge uniformly mixed with the sewage in presence of the necessary air. A large amount of work has been done in this country and also by Mr. Chalkley Hatton at Milwaukee and Dr. Bartow at the University of Illinois in collaboration with the writer, and the experimental plants of various dimensions capable of dealing with quantities varying from 60,000 gallons to as much as 2,000,000 gallons per day are in course of operation or construction.

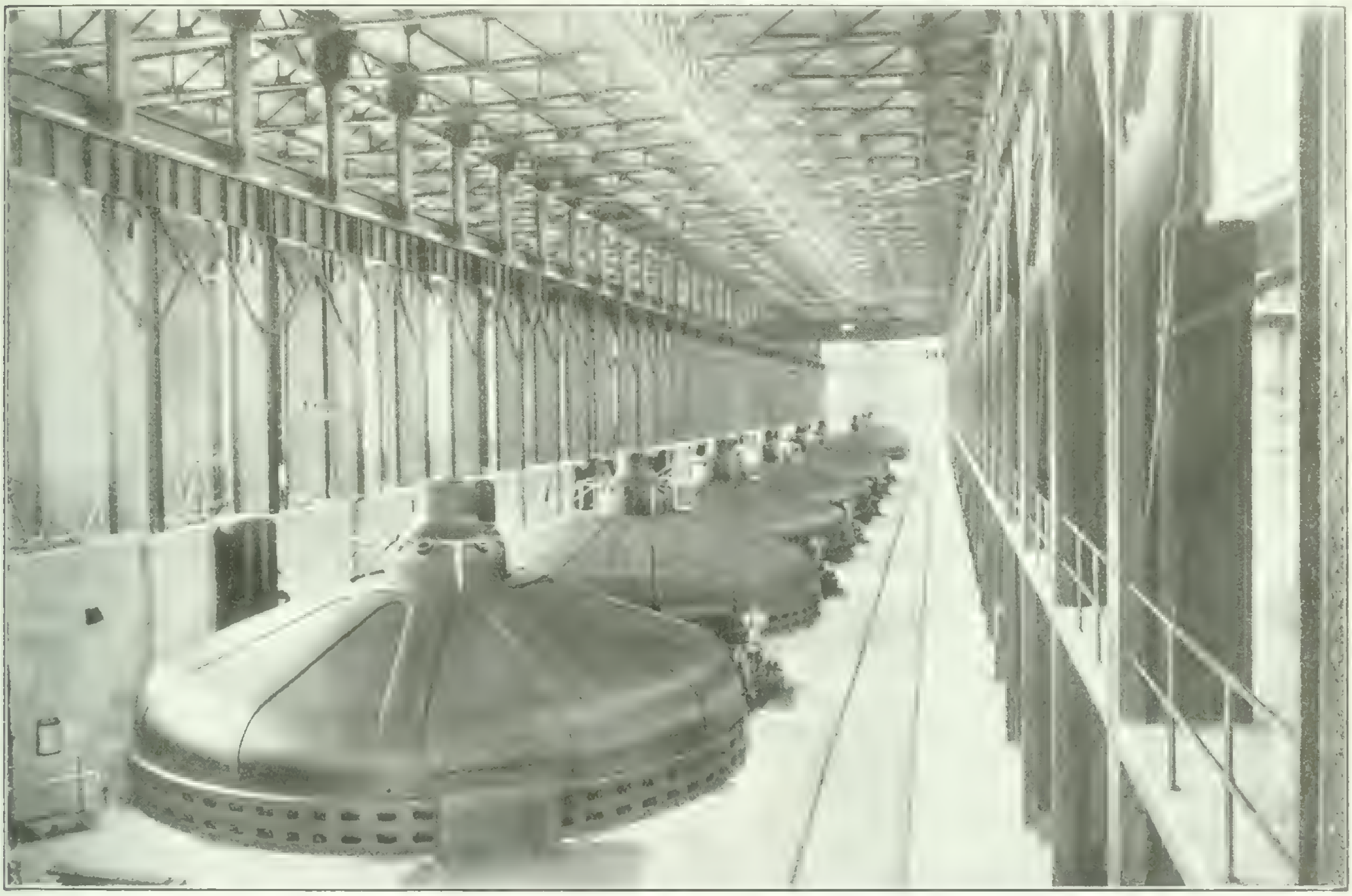
In all comparisons of cost between one process and another it is essential that result should be compared with result. Unfortunately, this rule is not always adhered to and a given process, *e.g.*, is said to be cheaper when on examination it gives much less satisfactory results. Where strict comparison is made the advantages of the activated sludge process are, in the majority of cases, beyond question, and the writer considers that any further large expenditure on works of the conventional type is—in view of the results already obtained—seriously to be deprecated.

HYDRO-ELECTRIC POWER IN EASTERN ONTARIO.

Representatives of Eastern Ontario municipalities have recently taken up with Sir Adam Beck, chairman of the Hydro-Electric Power Commission, the question of supplying them with power and radial lines. There has been but little activity as regards the development and transmission of hydro-electric power by other than private companies in Eastern Ontario in recent years, during which time the western peninsula has been experiencing phenomenal rural and urban improvements as a result of the supply of power and equipment furnished by the Commission. This delay in Eastern Ontario has been largely due to difficulties of a technical nature existing between the Federal and Provincial Governments as regards the water power development in the Trent Valley. In this connection Sir Adam made an important announcement to a delegation which waited upon him on February 1st. He stated that the existing difficulties had been practically removed, subject to the approval of the two parliaments, and, if these bodies corroborated the proposed agreement, the province would have control of the future development of water powers within its boundaries. When the necessary legislation giving effect to this understanding has been enacted, the municipalities in Eastern Ontario may expect a betterment of the situation.

CEDARS RAPIDS POWER DEVELOPMENT.

MESSRS. Henry Holgate and Julian C. Smith read papers last fall, before the Canadian Society of Civil Engineers, on the design and construction of the Cedars Rapids Power and Manufacturing Company's hydro-electric plant at Cedars, near Montreal. On December 2nd, 1915, R. M. Wilson, chief electrical engineer of the Montreal Light, Heat and Power Co., followed with a paper on the electrical design, construction and tests. These three papers jointly give a very complete record of the entire work. Brief abstracts of Messrs. Holgate's and Smith's papers appeared in *The Canadian Engineer* in the issues for November 18 and December 16, 1915, respectively. Following are a few of the most interesting points covered by Mr. Wilson's paper:



Interior View (Looking North) of the Power House at Cedars Rapids, Showing Some Important Structural Features and Illustrating the Arrangement of the Nine Units.

The generating plant consists of nine 10,000 kv.a., 6,600-volt, 3-phase, 60-cycle, vertical units, and three 1,250 kv.a., 2,300-volt, 3-phase, vertical exciter units. Voltage regulators are installed on each unit, maintaining a steady voltage and preventing cross-currents between the units. The main generator busbars are not in the power house, but are installed in the transformer house. The power and transformer houses are 800 ft. apart, connected by feeder cables.

Size of Units.—The design of the generating system was the main point in the consideration of the electrical layout, and had to be worked out in conjunction with the water-wheel design. Mr. Smith explained in his paper why the vertical type of unit was adopted. The next step was to determine the size of unit, having regard for contract obligations that are most onerous as regards continuity of service.

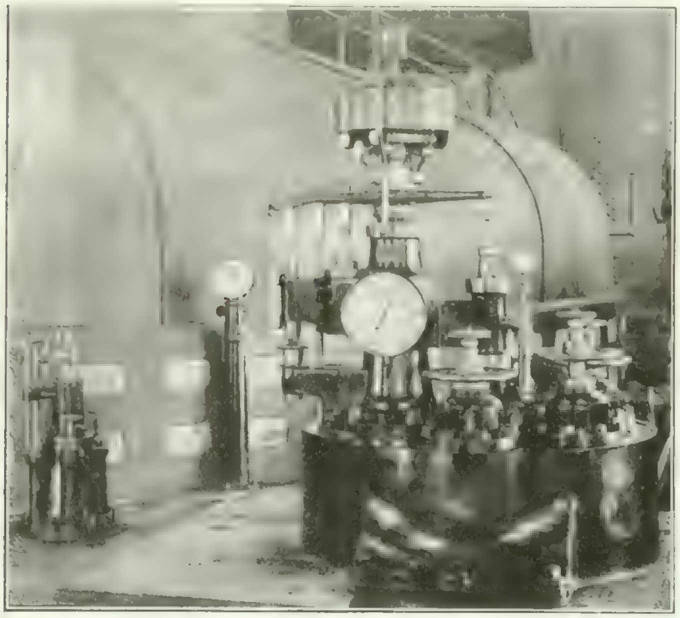
Two sizes were considered, *viz.*, 15,000 kv.a. and 10,000 kv.a. The smaller unit was adopted because: (1) with the larger unit, too great a percentage of the plant capacity would be put out of commission by the failure of any unit; (2) 15,000 kv.a. vertical units had never been constructed and the company did not wish to experiment; (3) the cost of other apparatus, such as cranes, bearings, etc., would have been greatly increased, owing to the excessive weight of the larger units. The weights of the rotor and stator of the smaller unit are respectively 213,000 lbs., and 146,000 lbs. For a 15,000 kv.a. unit, the weights would be 425,000 lbs. and 300,000 lbs.

A unit smaller than 10,000 kv.a. was not adopted owing to the larger power house that would have been required, and on account of the larger operating staff, etc., that a greater number of small units would have necessitated.

When the size of unit had been decided upon, the design was discussed with manufacturers prior to sending out specifications, in order to impress upon them the importance of securing the most economical ratio between the diameter of the unit and its height. The result was that the design adopted saved 7 ft. in height of power house, as well as reducing the cost of the hydraulic installation.

The generator specifications required that the stator be in four sections; that the design be for 75 per cent. power factor, and 25 per cent. overload for two hours; that full rated capacity must be delivered at a normal

potential of 6,600 volts; that full load rating in amperes at a voltage of 7,200 volts must be carried for several hours without damage; that the temperature rise must not exceed 45 deg. C. at end of a 48-hour run; that the



One of the Main Governors (Unit No. 9.)

iron losses must not increase more than 5 per cent. after two years' operation.

The efficiency guaranteed at full load was to be 94.5 per cent. at 75 per cent. power factor; 95.5 per cent. at 90 per cent. power factor; 96.1 per cent. at 100 per cent. power factor. The highest efficiencies guaranteed—at ¾ load—were to be 95 per cent. at 75 per cent. power factor; 95.8 per cent. at 90 per cent. power factor; 96.4 per cent. at 100 per cent. power factor.

The units installed have met the most sanguine expectations. The outside diameter of the stator is 37 ft. 4 ins., and the unit is the largest in diameter which has been installed to date. The height of the stator frame from the floor line is only 33 inches.

Excitation.—In providing for the excitation the usual practice of installing large D.C. units, water-wheel driven, was departed from. In their place were installed three A.C., 1,250 kv.a., 2,300-volt, 3-phase units, excited by an 18-kw. D.C. generator on same shaft and turbine-driven, also a bank of three 1,000 kv.a. transformers, which permits of one of the large units being used for excitation purposes in emergencies.

These A.C. generators furnish the energy for driving the individual motor generator sets for exciting the large units. This method was adopted because in case of trouble on an individual exciter set only one main unit would be affected; all auxiliary machinery would be A.C. motor-driven with low operating costs; it is easier to obtain automatic voltage control with individual generator exciter sets; the investment in cables, switches, etc., is lower; the cost of spare apparatus is reduced; and in emergencies one of the large units can be used.

Switchboards and Switchgear.—The dominant point kept in mind in design of switchboards and accessories was to obtain the most flexible system consistent with minimum initial cost and continuity of service. The double busbar arrangement was adopted and designed in such manner that a failure on any one section would not cripple the next unit. One main control and instrument board is installed in the power house. In the transformer house a control desk and instrument board are installed for controlling the step-up transformers and out-going lines. All switching apparatus has been installed in such manner that extension to the plant can be made without interfering with operation of present units.

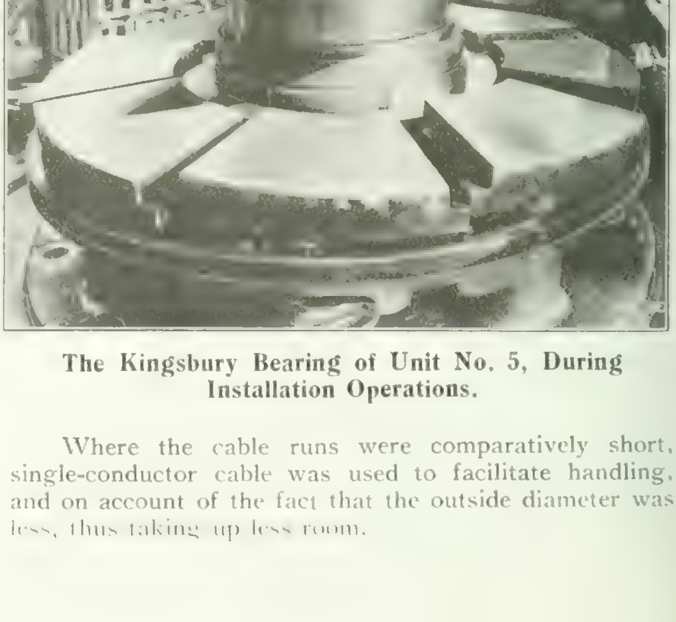
All busbar and switch structures are of reinforced concrete, which was adopted in place of brick because barrier work could be made thinner, loading on floors was much less, and it was easier to obtain greater clearances for live parts to ground in same space. For switch cells and busbar structures, 277 cu. yds. of reinforced concrete were required, at an average cost of $58.70 per cu. yd.

The generators, exciters, switchboard apparatus, etc., were supplied by the Canadian General Electric Co., Ltd.

Cables.—All cables used on the main generators operating at 6,600 volts were installed for 13,200 volts pressure. Cables used for 2,300 volts operation are installed for 4,400 volts. The increased cost is more than offset by insurance against failures. Lead-covered, paper-insulated cables were used in all places subjected to moisture. All cables were designed with cross-sectional area of sufficient size to carry 50 per cent. over normal current continuously. All large single conductor cables on A.C. circuits have rope cores to minimize skin effect. In designing cables, 1,200 c.m. per ampere was generally allowed.

The most important part of the cable design was the size and kind to use on the main units connecting power and transformer houses. The final adoption was four 3-conductor, 300,000-c.m., lead-covered, paper-insulated cables per unit.

Some of the reasons governing this decision were: (1) Increase in apparent resistance of single-conductor lead-covered cables, carrying heavy currents at 60 cycles was found to be abnormally high; (2) the three-conductor cable was slightly cheaper in initial cost; (3) in the event of failure of one of the four cables, partial service could be obtained during repairs.



The Kingsbury Bearing of Unit No. 5, During Installation Operations.

Where the cable runs were comparatively short, single-conductor cable was used to facilitate handling, and on account of the fact that the outside diameter was less, thus taking up less room.

The cables were supplied by the Northern Electric Co., Limited.

Transformer House.—This building is of reinforced concrete, built on the unit principle, and contains about 1,825 units. It is 228 ft. long, 130 ft. wide and 90 ft. high from basement floor to roof. The load per square foot on all footings is 2,500 lbs. This may appear small, but was due to the nature of the soil, which made heavier loading inadvisable.

In this building are the busbars, with necessary switches, etc., and the step-up transformers for the Massena and Montreal systems. The principal reason for having the step-up transformers removed from the power house was the desire not to have large quantities of oil in too close proximity to the generating apparatus. There was also considerable saving effected in the rock excavation for the power house, and the arrangement permitted easier construction in regard to the exits for the transmission lines.

The auxiliary transformers were supplied by the Canadian Westinghouse Company, Limited.

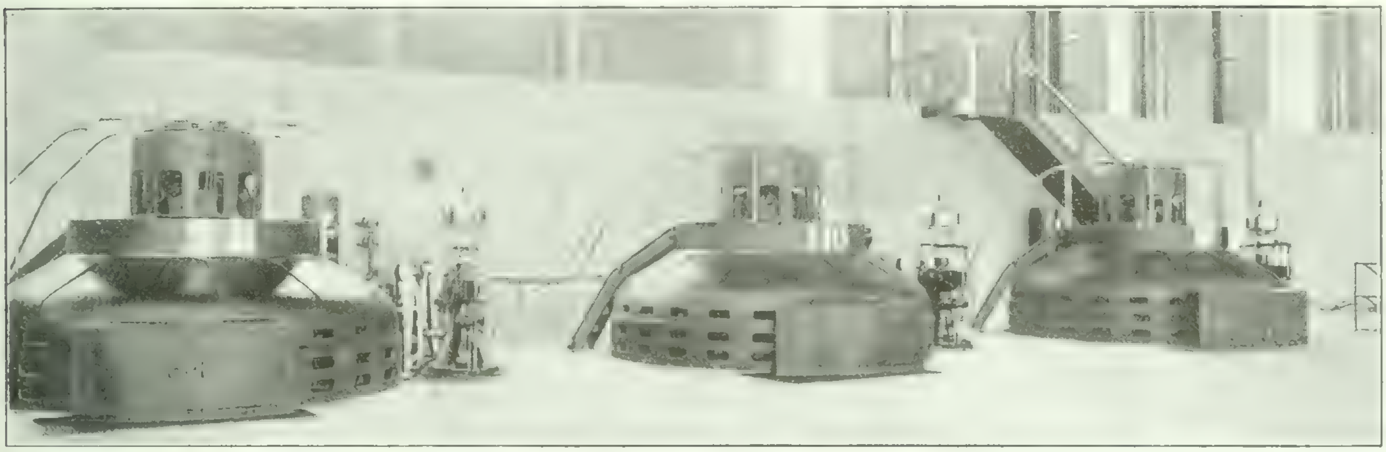
Tests.—The tests carried out on the generating equipment were for efficiency, field characteristics, regulation, heat runs, overspeed, high potential and oscillograph. The efficiency test was made by the method known as the Decelleration Core Loss Test. The field characteristics at different power factors were determined by means of the no-load saturation and the short circuit impedance curve. The regulation was taken as the drop in voltage expressed as a percentage of no-load volts. Heat runs were made with various power factors and loads, with different degrees of ventilation. The overspeed test was made by throwing the water-wheel gates wide open and unit allowed to rotate without load or brakes. A high potential test of 15,000 volts was made on armature windings and 2,200 volts on field coils for one minute. Oscillograph tests were made under all conditions of short circuits, including single-phase and three-phase, as well as tests for wave form under different power factor conditions.

One interesting test was made by short circuit under normal load. It was performed as follows: The unit was loaded by means of a water rheostat, located in the gate house, and the unit short circuited by means of a special oil switch.

At the moment of short circuit the field current jumped from 305 to 560 amperes, and the armature current to about 8 times normal current, the speed of the unit raising from 56 r.p.m. to 66, then back to 53, and finally settling down to 56. The wheel gate opening as a result went through a large variation, causing a considerable water surge in the gate house.

Cost.—The following summary contains the costs of the electrical installation for the first development of 100,000 h.p.:—

	Per kw.
Generators, exciters and blowers	$10.04
Switchboards and high-tension switchgear	2.18
Switch cells and bus structures	.26
Control cables and conduits	.54
Main cables and ducts in power house and transformer house	.23
Feeder cables, ducts and trestle	1.40
Auxiliary power cables and conduits	.28
Auxiliary transformers	.22
Auxiliary switchboards	.37
Storage battery installation	.11
Lighting system	.19
Heating system	.19
Miscellaneous	.24
Total	$16.25



The Exciter Units, with Their Governors.

These costs include engineering supervision and interest during construction.

The total cost of the transformer house, including crane, turn table, transfer truck, etc., was $3.02 per kw. The cost per cubic foot was $0.098; per square foot of floor, $0.251. The floor area is 1.2 sq. ft. per kw.

Operation.—The plant was first placed in commercial operation on December 27th, 1914. The load has been built up gradually until now the plant is operating at its maximum output with a daily load factor of over 90 per cent. Three shifts of 8 men each, and one operating superintendent, comprise the staff. The superintendent is W. G. Hullett. Very little trouble in operation has been experienced to date, everything working out smoothly.

COPPER LINING FOR TUNNEL.

Bids are being solicited by the Board of Water Supply of New York City, calling for furnishing and placing copper lining in a portion of the city tunnel of the Catskill water supply aqueduct. The actual length to be lined is about 1,200 ft. of 12-ft. tunnel. The copper generally will be 5/64-in. in thickness, and the sheets will be joined by brazing and attached to the surface of the existing concrete lining by bolts fastened into the masonry. After completion, the tightness of the brazed joints is to be tested by light water pressure on the back of the copper lining.

TUNNELING AT ROGER'S PASS.

At a sectional meeting of the Canadian Society of Civil Engineers, held in Montreal on January 12th, Mr. J. G. Sullivan, chief engineer of western lines for the Canadian Pacific Railway, read a short paper descriptive of the construction of the Roger's Pass tunnel up to the meeting of the east and west headings on December 20th last. This important work is referred to on another page in several paragraphs of the address of Mr. F. C. Gamble, retiring president of the Society. Several articles have previously appeared in *The Canadian Engineer*, descriptive of the scheme, of which the tunnel is a part, for the reduction of grades, elimination of curvature, removal of snowsheds, and shortening of track, in the mountain division of the line.

In his address, Mr. Sullivan first reviews the development in traffic which ended in the decision of the company with respect to double tracking and grade reduction, and which directly resulted in the conclusion to proceed at once with the driving of the tunnel. The paper contains a number of interesting quotations from correspondence covering methods and speeds of driving and discussing the adoption of the pioneer tunnel method suggested by Mr. A. C. Dennis, superintendent for Foley Bros., Welch and Stewart, the contractors to whom the contract was afterwards awarded.

The principles worked out together by Mr. Sullivan and Mr. Dennis are those which have resulted in the record progress that has been achieved. The function of the pioneer bore has already been fully explained in these columns, and we present the following paragraphs from Mr. Sullivan's paper relating to the manner in which the work is carried out, it being remembered by the reader that the primary object of the bore is to facilitate blasting at any point in the tunnel without interfering with operations at other points.

The pioneer tunnel at the east end is located 50 feet to the north of the centre line of the main tunnel, and the pioneer at the west end is 50 feet south of the centre line of the main tunnel. The mode of operation is as follows: The drilling in the small headings is done in the usual manner, using in general Leyner drills, making an advance of 6 or 7 feet for each round of holes. The muck is shovelled by hand from steel plates into half-yard cars and hauled back, either by a mule or small compressed air locomotives, the latter being used after the haul got to be a considerable distance. The muck from the headings is carried out through cross-cuts into the pioneer tunnel, where it is carried back to a cross-cut, and there carried out on a trestle over the standard gauge tracks in the main tunnel and dumped into standard gauge cars, from which point it is removed to the fills in a similar manner to the muck loaded by steam shovels in the enlargement. The muck from the heading on the west end in a similar manner goes into the pioneer tunnel at a cross-cut, crosses back to the main tunnel in a cross-cut, where it is dumped into standard gauge cars. In the enlargement of the main tunnel the drilling is done well ahead of the shooting. At first the radial holes were drilled at right angles to the axis of the tunnel. This did not give the best results, and it was changed to a drilling showing an inclination of about one in four away from the direction in which the tunnel is being driven. The muck is all loaded by steam shovels into standard gauge 12-yard capacity dump cars. The shovels have dippers of 1¼ cu. yds. capacity and are worked by compressed air. The cars are hauled to the mouth of the tunnel by standard gauge compressed air locomotives and from there by standard steam locomotives.

Doors are put in the cross-cuts between the pioneer and the centre heading. All of these doors are kept closed back of the shovel, and when shooting takes place in the enlargement of the tunnel the door at the first cross-cut beyond point of shooting is opened. This creates a very strong draught back over a pile of freshly shot muck and makes conditions such that the men can return to work in ten or fifteen minutes after a shot. The shooting of the muck in the enlargement of the main tunnel is done in the following manner: One round of holes is shot at a time, the holes in the bottom of the tunnel being shot in advance of the holes on the sides or on top. In some cases the top holes are not shot until all of the bottom holes have been shot out. Usually six or seven rounds of holes are shot before the steam shovel starts cleaning up the muck, that is, a distance of 30 ft. to 35 ft. The shooting is generally continued until the tunnel becomes so full of muck that no more shooting can be done. The largest amount that was ever shot at one time was on November 20, 1915, when 84 feet was shot in eleven hours.

In conclusion, Mr. Sullivan states that all expectations as to speed have been more than realized, and that for any rock tunnel where the rock is of sufficient hardness to stand until after the mucking has been done, this method can be worked successfully and a speed of three miles per year can easily be made at a much less cost than tunnels driven at the same speed by the European method; and furthermore, the radial shooting has proven that a great deal less over break can be expected from this method than where holes are put in parallel with the axis of the tunnel.

AN UNUSUAL RAILWAY IN THE WEST.

The Hudson Bay Company owns a very unique and serviceable little railway which it constructed about 60 years ago on Grand Island, in the Athabasca River. It is a portage railway whereby some dangerous rapids are avoided by the passenger and freight traffic on the river. According to the Engineering News, the railway has shown a profit of $1,000,000 in 60 years' service although its cost, including equipment, was less than $1,000.

The track consists of strap or bar-iron rails on wood stringers laid upon wood ties. The equipment consists of two flat cars. The freight rate is $2.50 per ton, the men handling their own goods and shoving the cars along the line.

A scow going inland (downstream) lands its cargo at the upper end of the island and then goes down the rapids in about 70 seconds. The vertical descent is about 65 feet. In the quiet (but swift) water below, the crew hold the boat with the oars till they can pick up a timber thrown out from shore and attached to a light line. With this a heavier cable is pulled out, and the boat then hauled to shore for reloading. A boat coming out upstream is either taken through the rapids by tracking or is hauled across on the railway.

Mr. Alcide Chausse, city architect of Montreal, presents the following figures relating to building in a number of Canadian cities in 1915, as compared with figures for the previous year:—

	1914.	1915.
Montreal	[illegible]	$7,486,221
Toronto	20,684,288	6,651,880
Winnipeg	12,160,950	1,826,300
Ottawa	4,307,020	1,605,100
Hamilton	[illegible]	[illegible]
Vancouver	[illegible]	[illegible]
London	[illegible]	[illegible]
Halifax	870,220	1,063,085

GENERAL PRINCIPLES OF ROAD IMPROVEMENT

By W. Muir Edwards,
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AMONG the few subjects which are of vital interest to all members of the community, the construction and maintenance of public roads should surely find a place. To the casual observer it might appear that as the network of railways becomes closer, the outlay required for public roads should decrease. The exact opposite is the true state of affairs. The construction of branch railways means a more dense settlement of the country, increases, therefore, the burden on the tributary roads, and thus justifies an increased expenditure on public highways. Improved financial conditions coincident with, or following closely upon, railway expansion results in an increased use of motor-driven vehicles both for business and pleasure. The increased speed of this class of traffic requires improvement of roadways already in existence, introduces new factors in the construction of projected highways and makes more difficult the maintenance of all public roadways.

In considering the economic principles governing highway improvement and maintenance, it is well to distinguish between the several classes of both roadways and traffic. Considering first the former, we might make the following division, confining ourselves, for the sake of simplicity, to four sub-heads, *e.g.*, (1) Roads with a hard surface passable at all seasons for any type of traffic; (2) roads passable at all seasons only for slow traffic, and for the remainder of the year for fast traffic; (3) roads impassable at certain seasons of the year for all but light traffic, and for the remainder of the year passable for both slow-moving loads and fast traffic; (4) roads as above, except that for the remainder of the year slow-moving loads only can be accommodated.

Any passageway to which we apply the term "road" should come at least under the fourth of these classifications. Such a roadway can be successively raised into the higher classes at a cost for each improvement capable of definite estimation. The cost of such improvements, together with the cost in the first place, is affected greatly by local conditions, but in general it might be said that the cost of obtaining the first type of roadway is much greater than is involved in any of the other three. The raising of the fourth to the third is a matter of upkeep. To obtain the second from the third may require some additional constructional work, the main question, however, being upkeep, but the construction of a road with a hard surface serviceable for all traffic at all seasons of the year is a comparatively costly piece of engineering work. This cost, together with suitable methods of construction, will be considered in a later article. The economic problem with which we are faced is to determine to what extent we are justified in making the expenditures necessary to obtain one of these types of roads. All will agree that a road connecting each quarter section with the point where delivery of produce may be made and at which supplies may be obtained is essential and should be provided. What we must consider is just how much expenditure is justified in order that roads of the third, second or first class may be obtained and equally important how shall the acquired expenditure for any of these types be allotted.

The benefit accruing from improved roadways is not alone directly financial, but also that due to improved social and domestic conditions in the community. It is well to emphasize this latter benefit since it is not possible to demonstrate to a farming community that, on a purely financial basis, they are justified in spending any considerable sum in road improvement except in so far as such expenditure is devoted to the elimination of features which would otherwise unduly limit the maximum load which may be hauled at any season of the year. For example, an expenditure might be made to reduce a grade which at all seasons affects the maximum load, but would not be justified if applied to making passable at all seasons of the year a road which for the greater portion of the time is passable with reasonably heavy loads.

The above may not be in accordance with many of the statements of the ardent advocates of "good roads." However, in dealing with the purely financial side of the question as it affects the greatest user of the roadway, *i.e.*, the farmer, it must be remembered that he is primarily a raiser of produce, and secondly, at times which he can more or less select, a freighter of this produce to a shipping point and of supplies to his farm. The dairyman and market gardner do not come under this general statement, but form as yet a small proportion of the farming community and the tonnage they move is small compared to the total produce of the farm. Indeed, even in ordinary farming a very considerable proportion of the produce transports itself to market on the hoof and is not concerned as to the class of road over which it is driven. Moreover, in figuring the cost of the remainder of the farm produce which is hauled to town and which is affected by the classification of the roadway current freight rates cannot be fairly applied.

In other words, in dealing with the saving to the farmer we must not figure the cost per ton-mile of marketing produce as though this were done by a man and a team whose sole business was the hauling of loads. If you asked a farmer for a price to freight ten tons to a farm five miles away he might quote you $7.50, or a rate of 15 cents per ton-mile, but if you asked the same farmer what it cost him to haul ten tons of his grain to an elevator five miles away he might conceivably answer "nothing." This is, of course, not strictly accurate, but unless there is work for the man and team on the farm which must be done by some one else, the cost is certainly not $7.50. So that the sum of money involved in the transportation question is not as large as in many cases it is made out to be. Again, the saving in being able at any time to send his produce to a shipping point, is often overestimated except in special types of agricultural activities.

As has already been stated, there is no question as to the financial necessity of a road upon which the farmer may get to and from his point of distribution and supply. The raising of this road from the fourth to the third class involves little expense, but the improvement into the second, and assuredly into the first class must be justified in addition to financial gain by the comfort of driving over a good road rather than a poor road, the increased ease and possibility of frequent intercommunication and the improvement into community life generally. It is difficult to put these benefits into dollars and cents, but they are very real nevertheless. That much of these benefits, not now enjoyed, may be obtained at a reasonable outlay will be pointed out in a later article of this series dealing with country roads.

The traffic in the roadways might be divided into classes, according as it affects construction and maintenance. We will again only attempt four such divisions, *i.e.*, (1) horse-drawn vehicles, loads 2 to 3 tons, speed 2½ to 3½ miles per hour; (2) horse-drawn vehicles, light loads, speed 6 to 8 miles per hour; (3) motor vehicles, loads 10 to 20 tons, speed 10 to 15 miles per hour; (4) motor vehicles, load about 1½ tons, speed 20 to 60 miles

per hour. Again, as a basis of apportioning cost, we might make a division into local and through traffic. The former might be defined as that originating in the neighborhood of, and centering upon, a local shipping and distributing point and the latter as originating in, and travelling between, the large centres of population. Local traffic might consist of any of the four classes, but except in the neighborhood of large centres where conditions are peculiar and deserving of special treatment, would in the main be comprised in the first two divisions with an addition of a small but growing percentage of the more moderate speed of the fourth class. Through traffic would be almost entirely of the fourth class.

On the basis, therefore, of the requirements imposed by the traffic and of the nature of this traffic we might broadly classify the roadways of the western provinces into main highways, branch highways and country roads. The main highways would be those required by conditions in the neighborhood of large centres and by through traffic. The cost of these might therefore be very well borne by the province at large, such revenue being obtained from the users thereof as may be deemed advisable. The branch highways would be the main arteries covering ing on the local centres. The type of construction might not be as heavy as in the case of the main highways, and the cost might be borne by the surrounding district, with possibly provincial assistance. The country road connects up each farm with the main or branch highway and the cost should be borne entirely by the local improvement district or by the adjacent land.

MUNICIPAL IMPROVEMENTS AT NIAGARA FALLS, ONT.

According to Mr. W. C. Jepson, who has been acting city engineer of Niagara Falls, Ont., in the absence of the city engineer, Mr. F. J. Anderson, who is now an officer in the 98th Overseas Battalion, the city laid 12,900 lineal feet of concrete sidewalks, for the most part 5 feet in width, during 1915. A small quantity of brick pavement was laid, the base being concrete and with grout filler and sand cushion. A short length of 1-course concrete roadway was also put down.

As nearly all paving work is petitioned for by the citizens, and as these petitions are often not presented before spring, Mr. Jepson could not give an estimate of the probable amount of paving which the city will lay in 1916. Last year some 2,500 feet of 18-inch main sewer and 9,500 feet of 10-inch and 12-inch laterals were laid.

The Muddy Run trunk sewer is now the chief sewer proposition for consideration. At the present time the Park Street sewer is overloaded. To relieve it and to dispense with Muddy Run Creek, which is practically an open storm sewer running through the city, it is proposed to build a trunk sewer estimated to cost from $250,000 to $300,000. Of this sewer, about 3,000 feet will be in tunnel under Huron Street, and 4,400 feet of it will be in the open, practically paralleling the course of Muddy Run Creek. There will be a 3 or 3½-ft. diameter pipe for sanitary flow and a 5½ or 6-ft. pipe to act as storm sewer. This project will be proceeded with as soon as the financial conditions improve.

Toronto's park area is now 1,561 acres. High Park, with 375 acres, is the largest, and the Island comes next with 330. The boulevard mileage as planned is [illegible] miles, and 1.80 has been constructed. Ravine driveways planned have a mileage of 6.38, and there have been partially constructed 7.27 miles.

DISTRIBUTION SYSTEMS, METHODS AND APPLIANCES IN IRRIGATION.*

By J. S. Dennis, H. B. Muckleston and R. S. Stockton,
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THE most important part of the distribution system is the farmer who is to use it. If the man is not successful, the project is a failure. When an irrigation project is proposed or built, its primary object is to make homes on the land. There may have been other reasons for its construction, but unless the first is accomplished, no matter how well the project is conceived, or how much engineering skill is shown in its construction, it cannot be considered a success.

The secrets of success are as follows:—

(1) A sufficient water supply. Many projects have been constructed in the past with little or no attempt to ensure a sufficient supply of water for the irrigation of the lands. The necessary assurance that the available sources of supply are sufficient, can be attained only after observation covering a long period of years. Such work is beyond the resources of any private individual or corporation and should be undertaken by the governments.

(2) Good construction. This must be considered as a term of which the meaning is relative. A quality or character of construction which would be considered necessary in an old and established country might be sinful extravagance under pioneer conditions. Many of the failures in new countries may be charged to setting too high a standard for the construction of the works. New countries find it difficult to raise capital but have little trouble in paying maintenance charges, and even if the ultimate cost is higher by reason of temporary expedients in first construction, the project may be better off in the long run. This is also true in a divided sense. It may pay to adopt a high standard in the large main arteries of the project on which the settler has to pay for the maintenance, and a much lower one in the distributaries where he does the actual work himself.

(3) A well organized system for transporting and delivering to the settler, the water on which he depends. Mere capacity to deliver water matters little to the success of the project. It must actually do so in the proper quantity and at the time when it is most required. It is true, too, that while a well organized operating force can go very far towards success, it cannot go all the way. Quite as much, or even more, depends on proper use of the water after it is delivered. To this end the settlers and the canal management must co-operate.

Where irrigation by flooding is the general rule, it is to the settler's individual interest that he obtain water in as large a "head" as possible at certain critical times, but it is manifestly impossible to build the whole canal system large enough to provide such a head for all the settlers at the same time, hence, it is to the interest of the community that the available supply be made to go as far as possible without restricting any person in the use of a practicable irrigating head. Evidently, these two requirements conflict and can only be reconciled by co-operation. Let the settlers so prepare their land and diversify their crops as to be able to take turns at the available supply, or else let them learn to get along with a small uniform head delivered continuously. Neither is impossible and both have been worked, but it is generally conceded that the former is the preferable arrangement.

Good Design.—It is also evident that proper design of the distribution system is of very great importance in successful management.

* From a paper presented at the International Engineering Congress, in San Francisco, Cal., September 20-25, 1915.

The distribution system for a large irrigation project divides itself into several parts, which although closely inter-related, present certain individual aspects in connection with the location, construction, operation and maintenance of these unit parts. These different parts of an irrigation system will be considered under the heads of Main and Secondary Canals, distributary ditches and the farm ditches used in irrigating individual holdings.

The managers of practically all large systems constructed in the last ten years have agreed as to the advisability of the policy of building the system complete to a delivery at the boundary of the individual holding or farm unit. The reasons for this are, first, the economy in cost and the engineering skill available for the location and construction work; second, the fact that a farmer starting in on a new place had enough to do during the first few years to prepare his land and build the farm ditches for irrigation. It may be pointed out just here, that one of the greatest sources of failure of new settlers on irrigation projects, is their inability or failure to suitably prepare the land and extend the distribution system without which their efforts at irrigation lead to disappointment and fault finding, and very frequently, to an absolute failure.

The engineering problems connected with the location and construction of the main canals are many and varied, but are well understood by the men who have followed this line of work. The important matters of general policy affecting this part of the system concern alternative use of timber and concrete or masonry for the structures, the duty of water and the method of delivery, the source of water supply and land to be covered. In Canada, the lands to be irrigated, the water supply and the construction of works must all be investigated and approved by the Dominion Commissioner of Irrigation, which insures that fake irrigation companies do not discredit legitimate irrigation enterprise.

The distributary ditches carrying water to the individual farm units do not present any very large engineering problems, but they do require, for satisfactory results, a knowledge on the part of the locating and constructing engineers of the detailed and practical requirements of irrigation as carried out in the field by the farmer and an experience in operating and maintaining such ditches and the various structures that are a part of them.

The size of the distributary ditches should be determined not by the duty of water, but by the size of the head of water that it is desired to deliver to each water user, and the method by which such water is to be delivered. No matter how the water right is stated, the practical requirements of irrigation necessitate a delivery by rotation in sufficiently large heads to insure the rapid and economical irrigation of the land with a minimum waste of water. Such a system enables the crops to be irrigated at the proper time and increases the duty of water. It enables the farmer to cultivate as well as irrigate his land, which is of fundamental importance. On large holdings, the rotation may be carried out as between different parts of the farm, but with smaller holdings a compulsory rotation is most desirable. The distributary ditches should be designed and built to carry a flow of at least two cubic feet per second to each delivery. This allows a satisfactory irrigating head for flood irrigation, which system is considered to be the best adapted for the majority of cases where the holdings are large, the slopes good and the crops consist largely of grain, hay and roots.

Distribution of Water to the Farm.—The proper place for main laterals is on the divide or watershed if they can get there, or as near as possible if they cannot. The distributing laterals should follow the line of quickest descent, to avoid interfering with drainage. This latter is not always feasible owing to the rectangular system of land subdivisions in use in some countries and a compromise must be arrived at whereby the laterals follow the survey lines as far as topography will permit. This compromise always results in some interference with drainage and almost always costs more in consequence. Another very important feature in the design of the distribution is the provision of a sufficient number of tail ditches. These are to carry surplus canal water into the natural drainage lines of the country and should not be confused with drainage ditches which are those built to assist the natural drainage lines in disposing of surplus irrigation water or precipitation. Tail ditches are an operating convenience, drainage ditches, an agricultural necessity. Under favorable, though unusual topographical conditions, it is possible to so arrange things as to combine the drainage ditches and the lateral system into one over a portion of their length. The system is not a good one, as it aggravates any tendency toward salting or alkali and sometimes results in silting up the natural drainage lines unless they have a very pronounced fall.

Distribution on the Farm.—If the distribution outside the farm is the vital point in successful operation, the proper distribution on the farm is the most important factor in successful agriculture. No matter how regular nor how certain the water supply to the farm may be, it is worse than useless if not properly applied to the land.

There are many methods of irrigation in use, the choice in individual cases resting on many factors, such as character of crop, soil, subsoil, slope, preparation of land, custom of irrigator, available labor and many others. No matter what method be used, the farmer must build on his own land a miniature system to distribute the water. Part of this system will be permanent and part only temporary to be ploughed each year. Economical and proper use of the water is impossible unless the land is properly prepared to receive it, and it is just here that many irrigation projects have come to grief through lack of consideration of the problems of the water user, and not extending to the man on the land such advice and assistance as will enable him to advance on right lines.

Construction.—It is not sufficient for economical operation that a system be well designed. It must be well constructed. It is not meant by this that the highest standard shall be used, but merely that what is done shall be well done. It is a question which is the most difficult to operate cheaply, a well designed, badly constructed system, or the reverse. If anything it is the latter, for faults in construction can usually be remedied but faults in location are persistent and in many cases impossible to correct.

This should not excuse bad construction, however. Bad construction is seldom cheap in the first cost and never economical. It is usually the result of too little attention to small details and to lack of proper supervision. Costly design may be easily almost nullified by cheap supervision. One very common cause of trouble is breaching banks. Sometimes this is attributed to omission in the specifications but it is generally due to non-observance of the provisions which are in them.

The methods and tools used in earthwork naturally vary much with local conditions. In North America, horse power and tools, except in the very largest canals, are well nigh universal. When manual labor is cheap, other methods would be used. The same applies to structures. A design or a material, or a method of construction suited to India would be out of place in Canada, and a design suited to a tropical climate would be alto-

gether wrong in a northern climate, when frost is one of the principal agencies of destruction. Again, too, construction by contract may be advisable under one set of circumstances, and the exact contrary in another. There is no doubt that there is great economy in building structures of a permanent type in the main carrying canals when the money available will permit of this policy. Such structures besides being more economical as to actual construction and maintenance through a series of years, also add to the reliability of the canals and this feature is a most important one in giving satisfactory service. The failure of a dam, headgate or drop, in a main canal at a critical time, may not only entail a considerable loss to the farmers individually and a large total loss, but does more than anything else to bring about dissatisfaction among the water users.

Maintenance.—One very important factor and a frequent cause of trouble, especially in co-operation schemes, is insufficient attention to maintenance and renewals. A structure shows signs of requiring attention, but for various reasons, such as lack of funds, or because it is no person's particular business, nothing is done. It fails in some part and is hastily patched up, finally it fails as a whole at a critical time and something approaching disaster may result. Proper attention at the right time would probably lengthen its life very considerably and would certainly avoid the disastrous results of a failure when such can least be afforded.

Engineering.—Another very important prevalent cause of trouble, especially in co-operation schemes, is cheap engineering. This does not necessarily mean cheap men in charge. On the contrary, it is not unusual to find expensive consulting engineers without sufficient funds to make the proper surveys when they are most needed. Almost invariably it will pay to spend a considerable sum on an accurate topographical survey of the whole area to be included in the project. There are very few projects where an accurate large scale topographical map would not save its cost many times over, but comparatively speaking, how few there are, where such a map is available on which to project and co-ordinate the whole system down to the last detail or even beyond. For instance, a settler needs aid or advice in preparing a difficult piece of land; with an accurate map available, a scheme can be worked out in the office and carried out on the field with little change; without it, a special survey must be made. Again, it is not unusual to find the work as a whole in very competent hands, but for lack of funds the details are placed in charge of inexperienced men who have to acquire their knowledge at the expense of the constructing organization, with a resulting cost far in excess of what it need have been had the proper skilled assistance been available from the start.

Management.—Many projects suffer from petty economies in the management. A competent manager is worth an adequate salary and should get it, for he can save its cost many times over. It is hard to convince canal companies of this fact and as a result we find costly projects in the hands of cheap managers with the inevitable result of unnecessarily high operating charges. Large corporate or government managed projects do not suffer to the same extent from this cause as the small co-operation schemes, but even then it is not unknown. The necessary qualifications for a competent manager, of course, vary with the condition under which the project is operated. The successful manager, who has been accustomed to Indian or Egyptian conditions, might fail utterly under conditions as they exist in North America.

So, also, the organization must differ. Some of the governing factors may be outlined as follows:

(1) The extent to which the settlers are organized, or, in other words, to what extent do they relieve the management of the whole or a part of the details of operation and maintenance?

(2) The size of the project. Evidently the organization of a project covering two or three hundred thousand acres must be more complex than one of two or three thousand.

(3) The type of the project. Distribution by open ditches must need a different organization from distribution by pipes, and pumping projects from purely gravity projects. Again, a project which is divided into units by well marked natural features differs from a project confined to one valley with one long straight-away canal. Character of construction also enters, as on it depends that which requires most supervision, operation or maintenance.

Another and very important factor is the character of the settler. By this is meant his race or nationality, the system of government to which he is accustomed, his habits and customs. The laws of the country are important, so also is the respect in which laws are held, considered as a national or racial characteristic.

COST OF DRILLING ANCHOR BOLT HOLES FOR QUEBEC BRIDGE.

The following is a detailed statement, for which we are indebted to Engineering and Contracting, of the cost, for labor and material, of drilling the anchor bolt holes for the Quebec Bridge. The holes were drilled with a "Calyx" core drill, the diameter of the drill being 4½ ins. and that of the core 3⅜ ins. The number of holes drilled was 176, and the number of linear feet drilled 800, or an average of about 4.6 ft. per hole. The holes were drilled through solid granite. The costs given include every item except power for operating the drills, the drills being driven by a 5-h.p., alternating-current, electric motor. It will be noted, from the following data, that the cost of drilling, including equipment but excluding power, was $2.50 per linear foot.

Labor.

Dougherty, at north shore	$ 263.60
White, at north shore	238.25
Brown, at north shore	16.50
Mooney, at north shore	51.80
Raymond, at north shore	72.10
Dougherty, at south shore	291.80
White, at south shore	285.40
Total labor	$1,219.45
Travelling expenses, Dougherty	40.22
Total	$1,259.67

Material.

Calyx shot drill	$ 450.00
Belting, 12 ft. 3 ins.	1.76
Shot, 2,000 lbs.	100.00
Express on shot	3.00
Drill spindle, 4 ft. x 6 ins. long, one	22.85
Shot feed complete, one	4.50
4-in. shot bits, eighteen	117.00
1-in. stop cocks, two	.1.86
4-in. core barrel plug, one	15.50
4-in. x 2-ft. core barrels, two	16.00
16-ft. 3-in. belting and rivets	9.53
Total material	$ 742.00
Total labor and material	$2,001.07

NOTES ON TUNNEL SURVEY WORK

METHODS OF DETERMINATION OF DIRECTION BETWEEN SHAFTS AND OF TRANSFER AND EXTENSION OF LINES UNDER GROUND.

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WHILE descriptions of tunnel constructions are fairly numerous, very little has been written about the methods of carrying out the surveys for such works and the following article is an attempt to make these methods plain to such engineers as are not familiar with the procedure usually adopted.

Usually when a contract is let for a tunnel or other work the contractor rushes his plant to the site and expects to start at once, so that it is important that all the surveys should be completed before the plant is placed on the ground. While this is not always possible, it is certainly advisable, since, if the location of the centre line of the tunnel is known, the engineer can generally arrange for the hoisting plant to be so placed as not to obstruct his vision; whereas if the plant is once erected on the site, it is difficult to get it moved and will probably result in the engineer having to offset his line, practically doubling his work.

In cases where a tunnel is driven on a straight line from shafts which are in view of one another or which can be seen from an intermediate point, no special survey is required, as a hub can be set on the highest point between the shafts and a line ranged to it from each of them. An accurate chainage should, however, be taken between the points so that the grade elevations of the tunnel may be determined or the survey connected with other parts of a system.

When, however, the shafts are in such a position that they cannot be seen from one another or when a curve is introduced in a tunnel, the P.I. of which cannot be seen from both shafts, a triangulation becomes necessary.

Before starting on the survey it is a good plan for the engineer to walk over the ground, following the proposed location as nearly as possible, as by this means he can get a good idea of the best way to arrange his survey work. Triangulation stations should be kept clear of the sites for shafts which are generally in some predetermined position; if this is not done the points will disappear as soon as the excavation is started, neither should they be placed too close to the shaft, as movements of the earth, due to settlement and also to vibration of the machinery, are liable to disturb them.

Points from which lines are to be given for driving tunnels should be carefully referenced to other points, as far away as practicable.

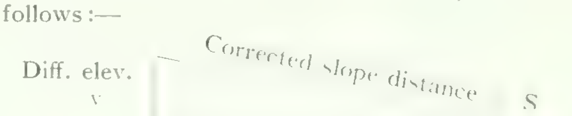
In making a triangulation survey contained angles should be read and not deflection angles, as this will tend to eliminate errors due to transiting the telescope. Each angle should be read accumulatively, starting from a point near zero and the mean of the total reading taken. This will eliminate, as far as possible, errors in the graduation which exist in all transits. Four to six readings should be taken and the angle read on both verniers. The object in not setting the verniers at zero at the start is to avoid bias. Station points may be made of wood or steel and should be strong enough to stand hard driving. If wood is used they should be made of seasoned timber about 3-in. x 3-in. section and about 12-in. to 15-in. long, driven to within 2 in. of the ground surface. When the stake is fixed, a flat-headed nail with a head about ½ in. diameter is driven in the centre of it and the centre of the nail is marked with a steel punch. Steel pikes are used for driving in concrete or macadam highways and should be from 4 in. to 6 in. long and ¾ in. to 1¼ in. diameter, sharpened at one end. These are driven flush and a punch mark placed in the centre as before. When giving a sight to the observer a steel arrow point is held vertically in the punch mark and a whitened board or paper held behind it; or a tripod may be set up and a plumb-bob hung directly over the point.

For plumbing over the punch mark at the instrument station, a wind shield made of a piece of stove pipe about 4 in. in diameter, with a hole cut in one side at the bottom, will be found very useful on windy days. The plumb-bob, which should be heavier than ordinarily used, is dropped through this and can then be brought to perfect steadiness in any weather.

While agreeing that the importance of the operations may justify in some cases the use of special appliances for making tunnel surveys, it has been the experience of the writer that most of these can be made by the engineer himself at a much less cost than they can be obtained from instrument makers and while not presenting so fine a finish, give just as good results in practice.

Bases are usually chained with 100-ft. steel tapes ½ in. wide, and the temperature at which the tapes used are standard, should be known.* The makers will supply this information or the tape can be compared with a government standard. Corrections are made on the basis of 0.01 ft. in 100 ft. for each 15° Fahr. rise or fall in temperature. Measurements should be made both ways and no attempt should be made to read even 100 ft. For chaining points between stations, small spikes or stakes may be used, lined in with the transit and marked with a punch mark or pencil.

The intermediate points should be determined by the slope of the ground and elevations taken at these points with a level. It is then a simple matter to reduce the slope measurements to horizontal measurements, which is done as follows:—



$$H = \sqrt{S^2 - V^2}$$

A reliable spring balance should be attached to the tape and a uniform pull of 12 lbs. applied when taking measurements. It is a good idea to set out, on a level floor or walk at headquarters, a standard 100 ft., so that a daily check can be made before starting work and corrections made accordingly.

The transit should have a 6-in. or 7-in. limb with verniers or micrometers reading to 5-in. or 10-in. sections by approximation if the triangulation is elaborate and to 20-in. for more simple triangulations. It should be fitted with cross-hairs set at about 70 in. to one another as this

* About 62° Fahr.

arrangement allows the sighting lines to be more readily centered and bisected than a vertical wire. An adjustable head for centering is also essential.

Fig. 1 shows a triangulation made for the purpose of determining the line of a tunnel about 3,200 ft. between shafts. This tunnel was driven through blue clay and presented no particular construction difficulties. When the junction was made the centre lines were found to be practically parallel and about ¼ in. apart. The district under which the tunnel was located was thickly populated and covered with houses and trees and no direct sight could be obtained between the shafts. A triangulation was, therefore, necessary.

The line paralleled a steep side hill which sloped to a river, upon the opposite bank of which were extensive flats. These offered an exceptional chance for securing a good level base and points D, E, F and G were established across the river.

The only line upon which a traverse could be run along the top of the hill was along a winding lane and a check triangulation was made on this route.

Starting at a point west of the first shaft which we will call A, another point, C, was established down hill on the left bank of the river and a point D was established on the right bank on the same line. The river was too wide for a direct measurement. A point H on the tunnel line was fixed by the position of a manhole and could be seen from A.

The angle A H D was then noted and also an angle P A D taken to connect the survey with other work, and the distance between A and C was measured as previously described. The outfit was then moved across the river to D and a line ranged and measured to point F and also from F to G. The angle A D F was then noted and an intermediate point E established at 200 ft. from D to enable the distance C D to be calculated. The angle D E C was then read. A point B east of the second shaft could be seen from both F and G, and angles were taken at these points to this station from the bases D F and F G.

The measured bases are shown full in the diagram and the calculated sides are shown dotted. Sufficient information having been secured to complete the preliminary triangulation, the work was plotted in the office and the calculations started.

The base measurements were first corrected for temperature and then reduced to horizontal distances and the survey was plotted from the information obtained. It was first necessary to calculate the distance C D across the river so as to secure a continuous measurement from A to D. This was done by solving the triangle C D E from which the distance was found to be 179.69 ft., which, added to the distance A C, gave a total distance of 870.50 ft. from A to D.

The triangulation system was then divided into three triangles, A D F, F G B, and A F B, which were solved in the order named, care being taken to make any adjustments necessary, any differences being divided out proportionately. The distance between the points A and B was thus computed and found to be 3,245.60 feet and the angles which it was necessary to turn at the points A and B from the bases to establish the centre line were determined.

The traverse was then checked by latitudes and departures and the distance A B computed to be 3,245.61, which was practically a dead check. A summary of this check is given.

Bearing.	Length of course. Feet.	Lat.	Dep.	Diff. Lat.	Diff. Dep.
S.	870.50	870.50	......	......	......
N. 73° .25′ E.	2,447.12	698.43	2,345.33	172.07	2,345.33
S. 89° .56′ .46″ E.	496.25	0.50	496.24	172.57	2,841.57
N. 13° .54′ .54″ E.	1,125.88	1,092.83	270.85	920.26	3,112.42
S. 73° .31′ .44″ W.	3,245.61	920.23	3,112.41	0.03	0.01

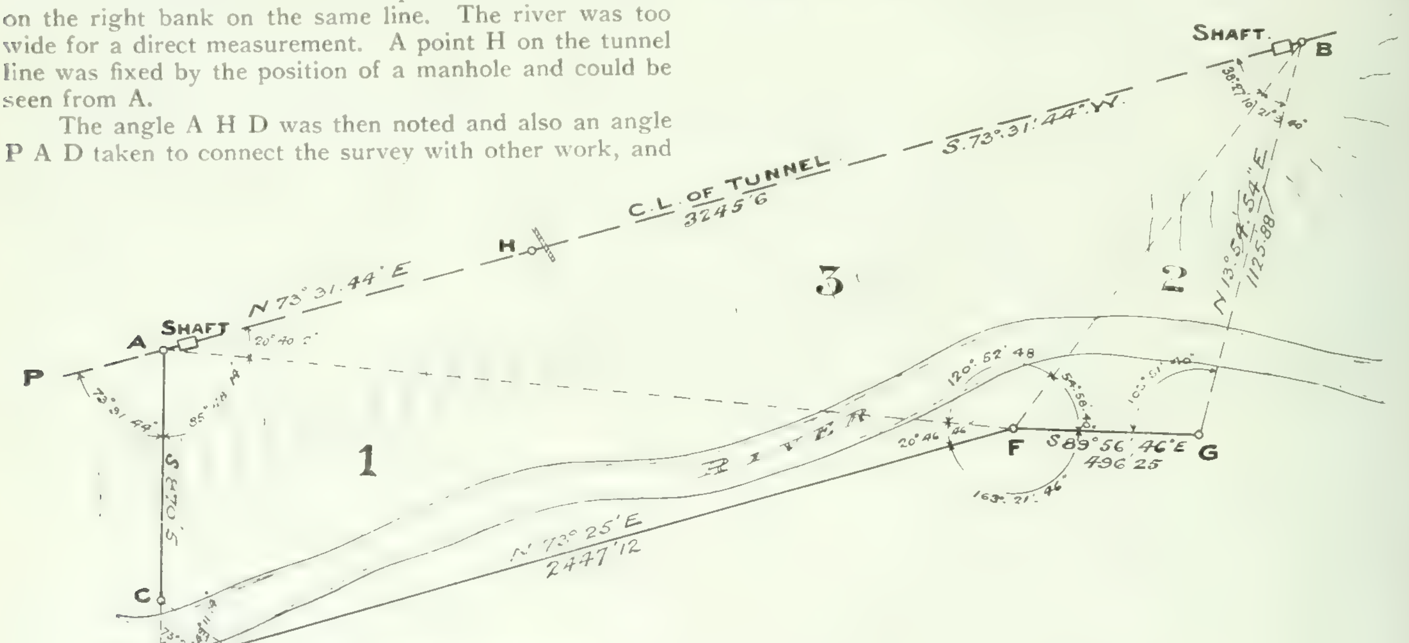


Fig. 1.—Bases Measured, in Full Line; Bases Calculated, Broken Line.

Upon working up the check traverse made between the points A and B along the hillside the results were found to agree very closely with those previously obtained.

The triangulation described is a fairly simple one, but the methods adopted can be applied to a more elaborate system if required.

Before construction starts, bench marks should be established well clear of each shaft for the purpose of fixing the grade elevations. They should, as far as possible, be placed so that the levelman can see both the bench mark and the shaft, from his initial set-up, midway between the points.

When a tunnel is projected under a city, following or crossing street lines, it is sometimes advisable on account of traffic interference, to make the surveys at night. The temperature is then more equable and the sight when illuminated, can be clearly seen by the observer. A box about 12 in. square with a front of tracing linen or frosted glass is used behind the sighting points and is illuminated in any convenient manner.

Having discussed the method of determining the direction between shafts, it is now proposed to give a short description of the method of transferring the lines underground and prolonging them until a junction is effected between the workings from adjoining shafts.

The first business is to lay out the working shafts, which should be upon the centre line if possible, although this is not always feasible. They should be long enough to give about 10 feet in the clear between the plumb-lines. As soon as the shaft has been timbered up and excavation started, a nail is driven into the timbers and a distance marked, showing depth from top of nail to subgrade. As soon as bottom is reached, line will be required by the miners for opening up the sidelengths.

The direction being known from a given point, the instrument is set up and an angle turned that will give the proper direction, or if a point has already been

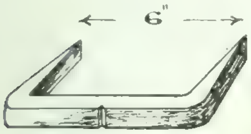


Fig. 2.

Fig. 3.

established on the centre line this is sighted on very carefully, so as to bisect the arrow or plumb-line. The telescope is then depressed and a point given on a brace on either end of the shaft; six-inch iron dogs, as Fig. 2, are then driven central to these points, care being taken to see that a line dropped from the dog will clear all obstructions below. The dogs being driven fairly tight, a small plumb-bob is dropped over them and the telescope focused on the cord, which is then moved so as to bisect the line of sight and a pencil mark is drawn on the face of the dog on either side of the cord. A file nick is now made between the lines about 1/16 inch deep and plumb-lines dropped to the bottom of the shaft. The transit cannot be used in the bottom until one or two tunnel lengths have been excavated and completed, but centres can be given with sufficient accuracy, by stretching a cord from the shaft into the tunnel and adjusting it so that it just touches either plumb-line.

Some engineers use a slow-motion screw device for bringing the lines into adjustment but the iron dog will be found to give as good results, and perfect adjustment can be secured by striking the shoulder of the dog with a hammer, so as to draw the line over as required. The usual practice is to use 25 B.W.G. piano wire for the plumb-lines, but the writer prefers to use a strong plaited line, such as is used by sea fishermen. If this is treated in a bath of boiled oil and dried it will remain waterproof and be free from kinks, and will give considerable service. It has the further advantages of being easier to handle and requiring a lesser weight to bring it taut. The piano wire requires at least 20 lbs. to effect this, while about 7 lbs. is sufficient for the cord. This difference in weight will be appreciated by the assistant who is responsible for carrying the weights around.

For use with the cord, the writer designed a plumbing weight as shown in Fig. 4. The body of the weight is in the shape of a shell with three vanes cast on the sides at angles of 120°. A screw top similar to those used on an ordinary plumb-bob is fitted and the line knotted through this. When the lines are dropped down the shaft the plumb-bobs are suspended in a pail of water and the tension on the cord will cause them to rotate. The vanes, however, soon stop this movement and the lines come to perfect steadiness in a very short time. Care must be taken to see that the plumb-bob does not touch the pail anywhere, or that the lines are fouled by any of the braces.

When it is desired to project the line into the tunnel, the transit is set up behind the back line, just near enough to clearly focus it, and the instrument is set on the centre of the line. The focus is now altered to catch the forward line which will probably be found to be off. The transit must now be moved either to the right or left and the operation repeated until both lines are exactly bisected when in focus. When this result has been attained a point may be given in the tunnel as far ahead as can be seen and two intermediate points should also be established on the permanent work. If, on checking the line at some later date, these three points are found to agree they may be adopted as a permanent base and the line extended from them.

For fixing centres in a brick-lined tunnel, a small steel dog, made as Fig. 3, is very useful. This is driven astride the keying course so that a space is left between the inside of the dog and the brick. When giving line a plumb-bob is suspended by a cord, with a lighted screen behind it and the line moved until the transit bisects it. A pencil mark is then made on either side of the line and a nick filed between them. The plumb-bob is now hung in the nick and the line adjusted by tapping the dog with a hammer until the line is truly bisected.

The ordinary tripod will not be found of much service underground as it is difficult to obtain a rigid foundation, on account of tracks, etc.

To overcome this, a platform is sometimes suspended from the roof and rigidly braced and the transit is placed upon this on a small tripod. The observer's seat should be independent of the platform. A sketch of such a tripod made of malleable cast iron suitable for a three-screw instrument is shown in Fig. 5. For an instrument of ordinary design, a screwed ring must be attached to the body of the tripod. The tripod shown in the sketch has V grooves cut in the top at angles of 120°. The ball at the foot of the levelling screws rests in these and the weight of the instrument will retain it in place. A hole about 3 inches in diameter is cast in the top of the tripod so that a small plumb-bob may be dropped from the instrument for centering purposes. This is very useful

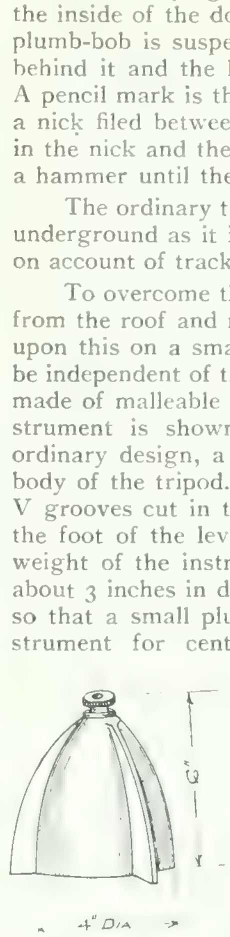


Fig. 4.

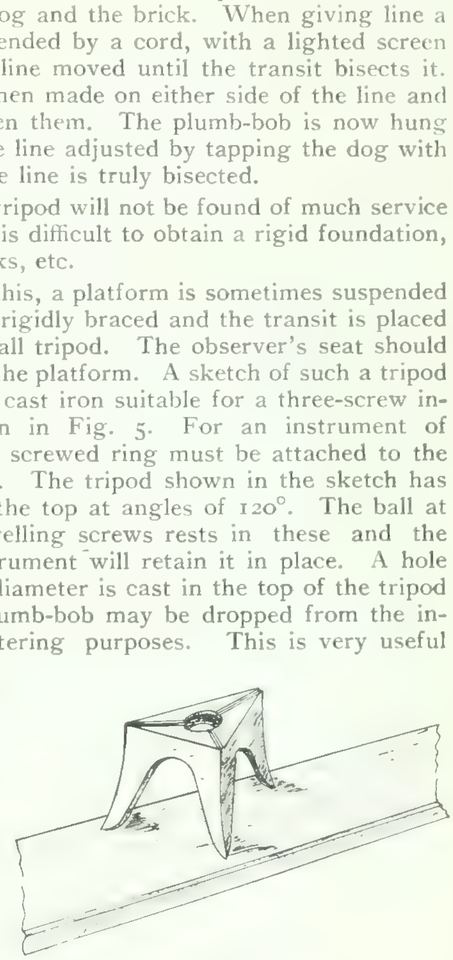


Fig. 5.

when ranging curves, for setting over the B.C. or other points.

For small tunnels up to 12 feet diameter it is best to use a plank wedged across the tunnel at springing for a platform. The top of the plank should be cleaned, so that the tripod can be moved easily upon it when making lateral adjustments.

When a curve occurs in a tunnel, the P.I. must be carefully located by a surface survey and then established in the tunnel from the information obtained, although this cannot always be accomplished owing to the point coming outside the limits of the tunnel section.

In such a case, when the B.C. has been established, the point is plumbed on to the platform and the transit set up over the point, a sight being taken on the back

tangent. The telescope is then transited and an angle turned off, which must be calculated from the distance of the face from the B.C. This point should be checked by again sighting on the back tangent with the telescope turned through an angle of 180° from its original position and then reversing and setting out the same angle as before, the mean of the two observations being the correct point on the curve. This process is continued as far as can be seen, when the transit is moved forward to an intermediate station and the usual procedure followed. When the curve is completed and the E.C. established, the transit is set over it, a sight is then taken on one of the intermediate points and an angle turned which will give the direction of the forward tangent. This should be very carefully checked as soon as the tunnel has proceeded far enough to give a good working base line for the new direction.

It frequently happens that the B.C. is so near the working face that a point on the curve cannot be focused. In such a case a line fastened to one of the back points on the tangent and passing vertically over the B.C. is stretched into the heading and a cord measurement taken from the B.C. to the approximate centre. The deflection angle is then calculated for this cord and the natural sine of this angle multiplied by cord length will give the length of an offset from the produced tangent, at right angles to it, that will pass through the centre, at the end of the cord.

Grade elevations are established as follows: The grade at the shaft being determined, a stout nail is driven in one of the top braces of the shaft and the elevation of the head noted. A steel tape is then lowered vertically down the shaft and another nail fixed about invert level. The difference between the heads of the two nails is then measured and the measurement subtracted from the elevation of the upper nail, will give the elevation of the head of the lower one. This can now be used as a turning point from which bench marks can be established through the tunnel. These are sometimes placed in the roof so as to be clear of interference from traffic, the rod being inverted when a reading is taken and the reading added to the H.I.

Engineers who have to deal with tunnel work will find many conditions arise that do not occur in ordinary practice but a little ingenuity will generally overcome all difficulties.

The methods outlined will be found sufficient to cover most of the problems that occur in ordinary practice, such as sewer, water or other tunnels, and will also form a basis for more intricate cases that may occur requiring special methods to determine the alignment.

SUBMARINE OIL PIPE-LINES.

Owing to the unfavorable nature of the comparatively shallow water close in to the coast, the Mexican Eagle Oil Company originated the idea of laying submarine pipe-lines to points where the largest tankers could be conveniently moored for loading purposes at any state of the tide and weather. They have three deep-sea loading berths at Tuxpam Bar with duplicate pipe-lines to each berth; the Penn Mexican Fuel Company also has two loading berths equipped with pipe-lines in duplicate. The lines terminate in 43 feet of water, which is below wave-action, and at the point where the pipe ends 120 feet of armored flexible hose is attached. The free end of the hose is closed by a blank flange and allowed to lie on the sea-bottom when not in use, its position being marked by a buoy with a chain sufficiently strong to lift it.

The rise and fall of the tide is approximately two feet, so that the depth of water, 43 feet, is sufficient for the largest tank steamers to load at any time. Tankers of 15,000 tons dead weight, drawing 28 feet, are regularly loaded.—Journal of the Royal Society of Arts.

ENGINEERS' CLUB, TORONTO.

The annual meeting of the Engineers' Club of Toronto was held last Thursday night, February 3rd, at the Club headquarters, about forty members being present.

The chair was occupied by Mr. C. H. Heys, president of the club, who, in presenting the annual report, made reference to the disturbed conditions of the country and their effect upon the membership.

A very healthy feature of the report is the present membership of the club as compared with that of a year ago. At the close of 1914 the total membership of the club was 455, whereas at the end of December, 1915, the total membership was 493. Furthermore, since then 49 new members have been accepted, making the present membership 542.

In the course of his address, the president paid a fitting tribute to those members of the club who are serving overseas. Of these, there are 28, and included in that number there is one on whom has been conferred the title of "C.M.G." and another, a member of the general staff, has won the D.S.O.

In view of the important engineering works that are being carried out and proposed in and around the city, the hope was expressed that with the large number of men who must necessarily be engaged on these works, together with the present membership, the year 1916 should prove a very successful one for the club in every respect.

Votes of thanks to the retiring president for his painstaking and able administration in 1915 and also to the secretary and the staff were proposed and most heartily supported.

The five new directors elected at the meeting to take the place of those retiring were: Messrs. H. G. Acres, Alfred Burton, J. B. Carswell, T. H. Stevens and M. P. White.

The full Board of Directors for the year will be as follows: Messrs. H. G. Acres, J. R. W. Ambrose, W. A. Bucke, Alfred Burton, J. B. Carswell, E. L. Cousins, A. G. Cumming, D. A. Dunlap, Arthur Hewitt, Chas. H. Heys, Chas. W. Power, L. V. Rorke, T. H. Stevens, M. P. White, T. S. Young.

Altogether the meeting was a very encouraging one and augurs well for a very successful year's work. After the meeting refreshments were served.

STEEL BILLETS FOR GREAT BRITAIN.

Mr. J. E. Ray, Trade Commissioner, Birmingham, has cabled the Department of Trade and Commerce, Ottawa, asking for quotations from Canadian manufacturers in connection with five hundred tons steel billets, three inches square, eighteen feet long, carbon point ten point fifteen; and same quality four square, two feet eight inches, carbon point three point thirty-five, earliest delivery c.i.f. Liverpool. Quotations are also asked c.i.f. Liverpool, earliest delivery for square steel billets, 200 tons each, size 2 inches, 2½ inches, 3 inches, 3½ inches, 4 inches, lengths 16 to 18 feet, carbon point 1 to point 15. It should be stated whether process is acid or basic. Firms interested are invited to cable Mr. Ray quotations forthwith.

The Department of Highways, Ontario, will be pleased to receive current catalogues and literature from manufacturers of and dealers in roadmaking material and equipment. Geo. Hogarth, Chief Engineer of Highways, Parliament Buildings, Toronto, Ont.

The 1916-17 estimates tabled in the House of Commons by the Minister of Finance recently provide for the organization and equipment of an Explosives Division of the Mines Branch, Department of Mines, Ottawa, for investigative work in connection with the manufacture and storage of explosives.

Editorial

CANADA'S CAPITOL FIRE.

Whether the great conflagration in Ottawa last week was the result of incendiarism is still a questionable matter. It is doubtful if the Commission which is to investigate the origin of the Parliament Building fire will be able to satisfy itself as to whether it was the crime of an enemy, the caprice of a maniac, or the outcome of an accident. But, at all events, the Commission will take cognizance of the rapidity with which the fire spread and of the inflammable nature of the interior of the building.

As an edifice of architectural beauty the central structure of the Ottawa group of federal buildings has been the pride of Canada for half a century. Older than the Dominion itself, its corner stone was laid in 1860 by the Prince of Wales, the late King Edward VII. While the original building cost $5,000,000, it is doubtful if an equal sum could replace the added embellishments and interior grandeur.

Its destruction has been serious; above all, in deplorable loss of life and in physical injury to many of our statesmen upon whose shoulders rests at this crisis grave responsibilities. Next in importance, probably, has been the obliteration of volumes of records, documents, parliamentary proceedings, papers, etc., not in the library or vaults. This loss will be felt for many years to come. There is also the serious disruption and distraction of an important parliamentary session. There is, lastly, the building loss.

That the fire leapt with incredible speed over the recently shellacked floors is common to the reports of many of the rescued. Induced by heavy drafts, a little headway, and the great edifice became a formidable fire trap.

It is to be hoped that Parliament will see its way clear to proceed immediately with the construction of a new federal home; that the design will demand the strictest devotion to the science of fireproofing, classical and grand though the architectural features may be made; that the idea of modern fireproof construction be extended without delay to other buildings of the Capitol group; and that the Government library, which by good fortune escaped with damage by water alone, will be among the first to receive attention in this respect. Had the fire destroyed the Ottawa library, Canada's loss would have been considerably greater than it is.

THE COAL SITUATION IN SASKATCHEWAN.

There is a serious shortage of coal in the province of Saskatchewan at the present time, according to press dispatches. It was announced in the Provincial Legislature on January 31st that in a certain village people are closing their homes and going to live at the hotel, the latter being the only place securing a supply of coal. The report states further that farmers were driving 50 and 60 miles in search of purchasable fuel. The severity of winter conditions during the month of January practically paralyzed transportation facilities in many sections, and the fuel situation has accordingly become acute.

This seems strange in a province possessing large coal deposits. According to a recent report prepared by Mr. D. B. Dowling, of the Geological Survey, the Souris area, comprising eight townships, is estimated to contain 2,304,000,000 tons of coal, while the western portion of the province contains, in an area of about 5,900 square miles, deposits probably aggregating 24,000,000,000 tons. The latter figure is an approximate estimate, but the Souris deposits have been calculated from investigation of actual thickness and extent of seams.

Coal is of many varieties, however, and the Saskatchewan deposits furnish fuel of the lignite class only. Some of the physical characteristics of this lignite in its raw state prevent its successful and economical use. As a result, the production during recent years has been in no way comparable with the increase in population. There has, accordingly, been an increasing dependence upon outside sources of supply, with the resulting dearth of fuel at the time of greatest need, *viz.*, when the railways are tied up owing to stormy weather.

There are 12 operating coal mines in Saskatchewan. In 1914 these produced 232,299 tons of coal, averaging $1.61 per ton. Although this is the largest output on record for the province, the average for the past four years has been 219,080 tons—extremely small in proportion to the needs of the province.

The importance of devising suitable methods of utilizing the large resources of lignite have been brought to the attention of the government and the results of investigations are now available. As large quantities of the same variety of lignite exist also in the province of Alberta, it is important that these investigations be followed up, although Alberta has a good supply of coals of harder and greater heat-giving varieties.

The Saskatchewan Government report, prepared about fifteen months ago by Mr. S. M. Darling, on the briquetting of Saskatchewan lignite, emphasized its adaptability for use for domestic and power purposes. In view of the high price of anthracite in the province, and more especially of the liability to coal famine, such as that now being experienced, the problem of developing local coal deposits should be thoroughly investigated.

THE WINNIPEG-SHOAL LAKE AQUEDUCT.

As a result of a number of cracks that have appeared in some of the constructed portions of the Shoal Lake aqueduct, considerable interest has been aroused in Winnipeg by statements reflecting upon the engineers of the aqueduct scheme and upon the adopted design of the works. The statements of Mr. M. T. Cantell, formerly employed in the engineering office of the District, have created a certain amount of misapprehension in the minds

The Winnipeg office of The Canadian Engineer has been moved from Room 1008 to Room 1208, McArthur Building. The new telephone number is Main 2663. Mr. G. W. Goodall remains in charge of the office.

of the citizens as to the real situation, and the Commissioners are at present proceeding to advise the public in detail regarding the condition of the work.

The Greater Winnipeg Water District is a corporation comprising, in addition to the city of Winnipeg, the city of St. Boniface, the town of Transcona, the rural municipality of St. Vital and portions of the rural municipalities of Fort Garry, Assiniboia and Kildonan, all of which adjoin the larger city. The system of water supply which the District is constructing is designed for a gravity flow of about 85,000,000 Imperial gallons of water per day from Shoal Lake, over a distance of about 95 miles, with a difference of elevation of approximately 300 feet. Since the first official announcement of the scheme, in September, 1913, many articles have appeared in *The Canadian Engineer* relating to the unique features of its design and the progress of construction of the portions already under contract. The part of the works to which the above-mentioned charges refer is a concrete aqueduct extending from Shoal Lake to within ten miles of the city of Winnipeg, a distance of 84.73 miles. The lengths, slopes, elevations and dimensions of its various sections will be found in an illustrated article which appeared in the issue of this journal for October 23rd, 1913.

The line of the aqueduct is through a practically unsettled country with large areas of swamps, marshes and muskegs. Throughout the greater part of the work so far completed an excellent foundation for the aqueduct has been secured at convenient depth, the subsoil for practically the entire distance being a sandy clay impervious to water. The deepest muskeg encountered by the aqueduct trench has been 15 feet. The foundation for the aqueduct along this section has been prepared by placing a gravel bottom protected by piling along the sides. The aqueduct over this portion is reinforced on account of the soft yielding sub-surface stratum. This is practically the only instance, we understand, where aqueduct foundations have as yet been required.

The sections which have occasioned the controversy are in a portion of the aqueduct extending through prairie where the cuts have been shallow and where the soil is of clay with no admixture of sand or grit and with varying moisture content. Difficulties in maintaining rigid and unyielding foundations in this region had been expected, but in order to build an aqueduct through this country that would have been proof against settlement and against cracks, concrete pile foundation would have been necessary, greatly increasing the cost of the work. It has been officially stated that before the specifications were written it was known that there were places in this section where settlement might occur after the work was constructed; but it was also known that the percentage of the total length which would be apt to settle would be very small and that it would be more economical to repair or even reconstruct these portions than to design an aqueduct that would not admit of any settlement at any point.

The portion in which settlement has actually occurred is where, in shallow cut, 4 feet of backfill had been placed over the arch. When the cracks appeared experiments were commenced to determine where the full amount of backfill, *viz.*, 4 feet, could be placed without injury to the concrete, in order to avoid a repetition of the condition under consideration. The engineers feel that no anxiety should exist, for the reason that settlement was expected, that the cracking is not of serious consequence and can be repaired at small cost, and that the behavior of these portions will be a guide in the construction of the remaining work. Of the 12 miles of the aqueduct completed, it is stated that considerably less than one-half mile has shown defects on account of settlement. On January 25th the Commissioners submitted a tabulated statement, from which the following percentages have been derived:

Percentage of whole aqueduct having cracks in invert ¼ in. in width	.27
Percentage of whole aqueduct having cracks in invert 1/16 in. to ¼ in. in width	.37
Percentage of whole aqueduct having hair line cracks	8.17
Total percentage of aqueduct having any crack	10.81
Percentage of whole aqueduct having no cracks that eye can perceive	89.19
Total	100.00

The statement is also made that only 2.64 per cent. of the completed work is sufficiently affected to require attention.

This is an official reply to the statements that were circulated on January 22nd to the effect that 8 or 10 miles of the aqueduct were absolutely useless and would have to be reconstructed at a cost of upwards of $2,000,000. These and other statements and allegations received such publicity in the Winnipeg press that the stability of the work completed to date was a matter of doubt in the public mind. The statement submitted to the District did not lay specific charges regarding construction, but had to do simply with the question of design. Mr. Cantell's own summary of his contentions are as follows:

"(1) That a sum of money in excess of $25,000 was paid by the commission for absolutely useless plans.

"(2) That the plans which were submitted by me would have fulfilled their requirements completely, and had one of them been accepted it would have cost approximately $1,125,000 less than the plans originally submitted.

"(3) That the designs at the present time being followed were prepared to be used only in rock, and they are being used in all kinds of soil, including clay and muskeg, and if used throughout the line, failure and very heavy additional cost are inevitable."

With respect to the expenditure of $25,000 "for absolutely useless plans," remembering Winnipeg's long and laborious search for a suitable water supply, little need be said. The scheme at present under way, estimated to cost over $13,000,000, is the result of many years' investigation of suitable sources and of thorough preliminary engineering study and design. Regarding the second contention, it is only necessary to observe that the plans submitted by Mr. Cantell no doubt received the consideration of the authorities. Mr. Cantell was in the employ of the District at the time when the adopted plans were under consideration. The validity of the third contention is inconceivable. The personnel of the engineering staff of the District, and the thorough preliminary investigation of the line of the aqueduct are known to our readers.

GARRISON CREEK STORM OVERFLOW SEWER, TORONTO.

The article in *The Canadian Engineer* for January 27th, 1916, relating to the construction of the main Garrison Creek storm overflow sewer and extensions, Toronto, presented some figures of labor and material costs. For a better understanding of the information given in this important section of the article, we have received from the author the following figures, upon which the labor costs were based: Engineers, 50c. per hour; foremen, $4 per day; bricklayers, 70c. per hour; signalmen, 30c. per hour; laborers, 25c. per hour (average; teams, $6 per day.

COAST TO COAST

Hamilton, Ont.—The question of a municipal gas plant came up at a meeting of the board of control last week when a shortage of gas was under discussion.

Kingston, Ont.—R. H. Fair, road superintendent, reported that during 1915 the sum of $21,416.25 had been expended upon the good roads system in the county.

London, Ont.—The agreement between the London Railway Commission and the Michigan Central Railway Co. for operating over the lines of the London and Port Stanley Railway has been signed.

South Vancouver, B.C.—Two piers of the bridge across the north arm of the Fraser River, between Twigg Island and Richmond, were swept away by ice recently, causing considerable damage to over 100 feet of the structure.

Toronto, Ont.—Plans and specifications are almost completed for the construction of an eastern entrance to Exhibition Park. The proposition involves a bridge over the railway tracks and the laying of a considerable length of street railway line.

Welland, Ont.—Last year $231,367.04 was expended by the county on the good roads system, upon which the government grant amounted to $77,222.35. About 83 miles have been completed to date out of a total of 133 miles, and the cost averages about $5,000 per mile.

West Vancouver, B.C.—Considerable damage has been done along the water front by recent heavy storms. A portion of the roadway of the Pacific Great Eastern Railway has been washed out, the service being temporarily interrupted. Several docks and light houses were also slightly damaged.

South Vancouver, B.C.—In connection with the present sewerage scheme which the municipality has under construction, Mr. S. B. Bennett, municipal engineer, reports that up to January 21, $154,000 had been spent on sewer construction, leaving a balance of approximately $146,600 to complete the work.

Quebec, Que.—The C.P.R. will lay out extended terminals in Quebec after the new station is completed, and business recommences under more favorable auspices. The company has extensive terminals; but the new layout will prepare for and anticipate the future. The Transcontinental will use the new station as well as the C.P.R.

Prince George, B.C.—The experiment which the Grand Trunk Pacific is carrying out of burning oil as fuel is regarded with interest by other railway corporations. The Grand Trunk Pacific uses oil on 700 miles of track, in the West. To make this possible it had to complete and set up oil plants at Jasper, McBride, Prince George, Endako, Smithes and Prince Rupert. The original cost was very heavy, but the advantages are many and important.

South Vancouver, B.C.—Construction work is under way on the Commercial Street trunk sewer, some 850 ft. of 48-inch and 580 ft. of 42-inch pipe being laid. The engineer has recommended a further length of 1,875 ft. of 42-inch pipe to extend southward, and estimates in connection with this a total expenditure of $17,800. The Albert Street trunk sewer requires about 550 ft. of pipe to complete it. The pipe used in these sewers is being manufactured by the Pacific Lock Joint Pipe Company.

North Vancouver, B.C.—The Amalgamated Drydock and Engineering Co., Limited, will establish, under the supervision of the Dominion Government, a drydock and shipbuilding plant on the north shore to cost about $4,500,000. The government has subsidized the undertaking and the city of North Vancouver has guaranteed bonds to the extent of $750,000. The graving dock will be 1,150 ft. long with an entrance width of 110 ft. and a depth at ordinary spring tides of 41 ft. over the sills. The dock will be in two sections, 650 ft. and 500 ft. long respectively. With the exception of the Lauzon dry dock at Quebec, it will be the largest on the continent.

Hamilton, Ont.—A meeting of the board of control was held last week at which Mr. J. N. Stanley, one of the engineers of the Hydro-Electric Power Commission of Ontario, exhibited the hydro-radial plans showing the proposed routes of the various entrances into the city. It is proposed to carry the passenger traffic through the centre of the city and to divert the freight traffic to the north end. The aim is to have the hydro-radials and the C.N.R. use a common right-of-way for freight. It is planned to have the city assume control of an electrically operated interswitching system for the use of all steam and electric railways subject to the rulings of the Board of Railway Commissioners.

PERSONAL.

F. T. LEVERSUCH, general manager of the London and Port Stanley Railway, has resigned.

E. B. STAVELEY, of Quebec, is the president for 1916 of the Quebec Association of Architects.

R. L. BRACKIN has been elected chairman of the Public Utilities Commission of Chatham, Ont.

R. WRIGHT has been appointed superintendent of terminals of the Grand Trunk Railway System.

JOHN DIGBY, formerly assistant engineer, has been appointed city electrical engineer of New Westminster, British Columbia.

WM. TANSLEY has been appointed district superintendent of the Canadian Pacific Railway, with headquarters at London, Ont.

WM. McNAB, M.Can.Soc.C.E., principal assistant engineer of the Grand Trunk Railway since 1907, has been appointed valuation engineer for the company.

A. W. WHEATLEY, vice-president of the Canadian Locomotive Company, Kingston, Ont., has been appointed president of the Lima Locomotive Corporation.

H. H. VAUGHAN, Mem.Can.Soc.C.E., vice-president of the Montreal Ammunition Co., Limited, has been made a vice-president of the Dominion Bridge Co.

H. M. SCOTT, Assoc.M.Can.Soc.C.E., who has been for a number of years in the employ of Mr. Henry Holgate, consulting engineer, Montreal, has enlisted for overseas service.

FRANK P. VAUGHAN, manager of the Vaughan Electric Company, Limited, St. John, N.B., was recently elected a member of the American Institute of Electrical Engineers.

H. N. KEIFER, of the Northern Electric Company, Vancouver office, has been elected secretary of the Vancouver section of the American Institute of Electrical Engineers.

F. M. RUTTER, for a number of years on the engineering staff of the Canadian Pacific Railway, has been appointed superintendent of transportation of the Eastern Ontario Section of the C.P.R.

A. G. GRAVES, city commissioner of Calgary, addressed the Calgary Branch of the Canadian Society of Civil Engineers a short time ago, the subject being "The Administration of Public Utilities."

J. L. MORRIS, C.E., O.L.S., of the firm of Morris and Moore, land surveyors and architects, Pembroke, Ont., and ex-mayor of the town, has been appointed engineer for the township of Pembroke.

C. H. RUST, city engineer of Victoria, B.C., read a paper last week before the Seattle Branch of the American Society of Civil Engineers, describing the design and construction of the Sooke Lake waterworks system.

ARTHUR CRUMPTON, M.Can.Soc.C.E., has been appointed assistant valuation engineer for the Grand Trunk Railway System. Mr. Crumpton has occupied the position of assistant engineer for the G.T.R. since 1892.

E. T. COCKRELL, secretary of the Burrard Inlet Tunnel and Bridge Company, Vancouver, B.C., has resigned. Mr. Cockrell is attached to the Sixth Field Company, Canadian Engineers, and is leaving shortly for the front.

F. BURCHELL, C.E., of the Nova Scotia Construction Co., and a graduate in civil engineering of Queen's University, Kingston, has enlisted for active service and is now a bombardier in the 63rd Battery at Fredericton, New Brunswick.

C. D. HOWE, engineer in charge of the construction of the Dominion Government grain elevator at Burrard Inlet, addressed the Vancouver Branch of the Canadian Society of Civil Engineers recently on the subject of elevator construction and grain transportation.

Lieut.-Col. C. H. MITCHELL, C.E., general staff officer of the Canadian corps in France, has received the D.S.O. in recognition of distinguished service at the front. Col. Mitchell is well known to our readers as a member of the consulting engineering firm of C. H. and P. H. Mitchell, Toronto.

Lieut.-Col. GEO. H. DAVIS, B.Sc., of Barnet, B.C., and formerly town engineer of Woodstock, Ont., who is in command of the Second Pioneer Battalion, which has been in England for the past few months, is seriously ill and in a hospital as a result of a fall from his horse. Col. Davis, who is an associate member of the Canadian Society of Civil Engineers, is a graduate of McGill University, Montreal.

ENGINEERING SOCIETY DINNER.

The 26th annual dinner of the University of Toronto Engineering Society was held on February 4th, Mr. W. L. Dobbin presiding. Upwards of three hundred graduates and undergraduates of the Faculty of Applied Science and Engineering were in attendance. Among the speakers were President Falconer, Dean Ellis, Lieut.-Col. W. R. Lang, Mayor T. L. Church, Geo. G. Powell, deputy city engineer, and L. M. Arkley, secretary of the Toronto Branch of the Canadian Society of Civil Engineers.

At the recent annual meeting of the Corporation of Land Surveyors of the Province of British Columbia the following surveyors were elected officers for the ensuing year: President, W. S. Drewry; vice-president, E. B. Hermon; secretary-treasurer, W. S. Gore; board of management, N. F. Townsend, F. C. Green, O. B. N. Wilkie, S. S. McDiarmid, J. Elliott.

OBITUARY.

The death occurred recently of Mr. Alexander Graham at the age of 51. The deceased was superintendent of construction in the engineering corps of the Department of Public Works, Ottawa, and at the time of his death was in charge of some government work under construction at Sturgeon Falls, Ont.

The death occurred recently of Mr. Guy Colin Carman, M.Can.Soc.C.E., in former days a prominent civil engineer and railway builder. The deceased was in his 80th year. When the Canadian Pacific Railway was under construction Mr. Carman was engaged on the British Columbia section of it. For many years he was engineer of the Cornwall Canal, from which position he retired some fifteen years ago.

CORRECTION.

In "Niagara River Pollution," on page 217 of last week's issue, the wording of the first paragraph conveys, by no means, a clear meaning owing to the inadvertant omission of one line and the repetition of another in its stead. The first sentence on page 218 should read: "It is likely that an intercepting sewer will be proposed to collect the discharges from the Seneca, Park and Orchard outlets and to convey the sewage to a projected disposal plant, presumably near the Orchard Street outlet." The sentence in question refers to a probable requirement of the coming report of the International Joint Commission regarding the pollution of boundary waters.

COMING MEETINGS.

NINTH CHICAGO CEMENT SHOW.—At Chicago, Ill., February 12th to 19th. R. F. Hall secretary, 208 South La Salle Street, Chicago, Ill.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Second National conference to be held at Chicago, Ill., February 15th to 18th, 1916. Secretary of the Advisory Committee, J. P. Beck, 208 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION.—Annual Convention to be held in Chicago, February 17 and 18, 1916. Secretary, E. S. Hanson, 538 S. Clark Street, Chicago, Ill.

CANADIAN LUMBERMEN'S ASSOCIATION.—At Ottawa, February 18th, 19th and 20th, 1916, annual convention. Frank Hawkins, secretary, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Meeting to be held in Cleveland, Ohio, February 21st and 22nd. Will P. Blair secretary, Brotherhood of Locomotive Engineers' Building, Cleveland, Ohio.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Thirteenth Annual Convention to be held at Pittsburgh, Pa., February 28th to March 3rd. E. L. Powers secretary, 150 Nassau Street, New York, N.Y.

CANADIAN MINING INSTITUTE.—Eighteenth annual meeting to be held at the Chateau Laurier, Ottawa, March 1, 2 and 3. Secretary, H. Mortimer-Lamb, Ritz-Carlton Hotel, Montreal.

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION to be held at Sohmer Park, Montreal, March 6, 7, 8, 9 and 10, 1916. General Secretary, Geo. A. McNamee, New Birks Building, Montreal.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

STORM SEWERS IN MOOSE JAW, SASK.

NOTES ON EXTENT OF SYSTEM, RECENT CONSTRUCTION, METHOD EMPLOYED AND COSTS—A WINTER UNDERTAKING TO PROVIDE LABOR FOR UNEMPLOYED.

By GEO. D. MACKIE, City Engineer-Commissioner.

THE city of Moose Jaw, like most of the other prairie cities, is drained on the separate system, and it is particularly necessary in Moose Jaw's case that every endeavor be made to prevent surface water reaching the sanitary sewers, as every gallon of sewage has to be pumped at the sewage disposal works before treatment.

Thirty-inch Segment Block Storm Sewer, Manitoba Street, Moose Jaw.

Thirty-inch Segment Block Storm Sewer, Manitoba Street, Moose Jaw.

With the rapid growth of the city during the last few years, entailing the construction of many miles of roads and streets, a large number of the natural water courses were destroyed, and as a consequence the necessity of constructing a system of storm sewers became absolutely necessary.

The city is intercepted by Thunder creek, which runs through it in an easterly direction and joins the Moose Jaw creek near the 11th Avenue subway. It is into these two creeks that the major portion of storm water discharges.

The first storm sewer was laid in 1906, but the construction of storm sewers did not keep pace with the city's growth, and, as a consequence, serious flooding took place every spring in the business section of the city due to the inadequate size of the storm sewers, or to the lack of them.

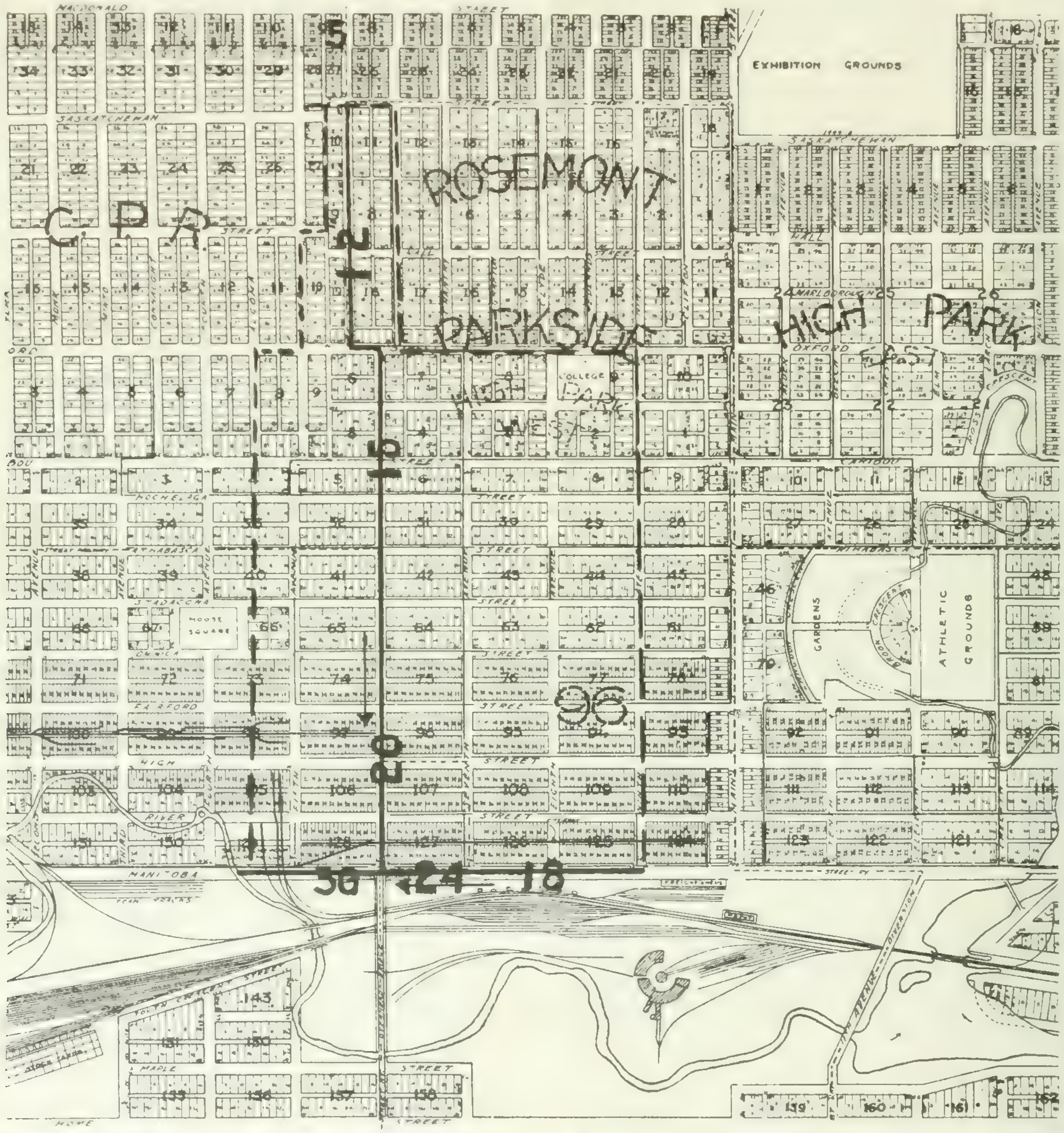
To partially remedy this state of affairs, the city authorized the construction of storm sewers to serve four different districts, and one of these sewers was constructed during the winter of 1914-15. This sewer is 7,744 feet long, and varies in diameter from 30 ins. to 12 ins., as shown on the accompanying plan. The area drained is enclosed by a broken line. The writer secured competitive prices for 24-in. and

30-in. pipes in tile, segment block and cement concrete, and the lowest prices received per foot were:

	Tile.	Segment block.	Concrete.
24-in.	$1.70	$1.80	$1.75
30-in.	3.32	2.30	2.60

Tile pipe was used for the 24-in. and segment for the 30-in. section. The tile pipe was supplied by the Redwing Sewer Pipe Company, and by the Alberta Clay Products Company, Medicine Hat, and the segment block by the American Sewer Pipe Company, Akron, Ohio. There are ten segment blocks to the ring in 2-ft. lengths weighing 230 pounds per lineal foot of pipe. The segment block was the first of its kind to be used in the city for sewer pipe, and was found perfectly satisfactory. The cost of laying the pipe is higher than for sewer tile of the same diameter, but this is more than offset by the difference in the first cost. The manufacturers claim that the segment block pipe can be laid at a cost of 1 cent per foot for each inch of diameter of pipe, and the writer believes this can be done under ordinary conditions, but as these pipes were laid in the winter, it required the services of two extra men tending fires, as in addition to heating the tile it was bedded in hot moist sand and covered with the same material to protect it from frost.

The accompanying views show the pipe as constructed in the ditch.



Section of City of Moose Jaw, Showing Route of New Storm Sewer, with Diameters of Various Sections Indicated.

The construction of this sewer presented no difficulties. Table I. gives an itemized cost of the various portions of the work per foot compared with the estimated cost.

In addition to the pipe line itself, 1,219 lin. ft. of connecting drains between catch basins and manholes were constructed. This pipe line averaged 4½ ft. in depth, and was frozen to grade. As two connections on each street intersection had to be tunnelled beneath the

street railway track, the cost (84.4 cents per lin. ft.) is relatively high. Twenty-nine manholes were built in the course of the work, averaging 267 ft. between centres. Four of these were of brick of irregular design, due to location and obstructions encountered; the remainder were of concrete of 1:3:5 mix, 3 ft. 6 in. inside diameter with a 9-in. wall. Forty-four catch basins were required, four being placed on each street intersection. These were of concrete, 2 ft. 6 in. inside diameter and a 9-in. wall. The benches of all manholes and the wearing surface of catch basins were given a finishing coat 1-in. thick 1 to 1 mix.

Table II. shows the cost per foot for manholes and catchbasins.

Table I.—Cost of Storm Sewers Per Foot.

Size of pipe	12-in.	15-in.	18-in.	20-in.	24-in.	30-in.
Material	Tile.	Tile.	Tile.	Tile.	Tile.	Seg. Block.
Length of section	1581 ft.	1509 ft.	1134 ft.	2086 ft.	635 ft.	797 ft.
Average depth	6.6 ft.	7.00 ft.	9.5 ft.	7.25 ft.	11.0 ft.	12.5 ft.
Nature of soil	Grey clay, 6 ft. frost	Clay and gravel, 7 ft. frost	Grey clay 5 ft. frost	Clay and gravel, 3 ft. frost	Clay and gumbo, 5 ft. frost.	Gumbo, 4 ft. frost
Yardage per lin. ft.	.65	.70	.90	.80	1.22	1.85
Cost per lin. ft. excavation	$ .65	$1.01	$1.03	$ .49	$1.34	$1.75
Backfill	$ .05	$ .07	$ .13	$ .13	$ .30	$ .40
Teaming, watching timekeeping, etc.	$ .14	$ .16	$ .16	$ .22	$ .22	$ .70
Pipe laying	$ .06	$ .06	$ .09	$ .12	$ .13	$ .52
Material	$ .60	$ .93	$1.19	$1.41	$2.01	$2.89
Total cost	$1.50	$2.23	$2.60	$2.37	$4.00	$6.26
Estimated cost	$2.00	$2.25	$3.00	$3.00	$4.00	$5.00

ginning of December and prosecuted to completion early in March of the following year. The temperature was below freezing at all times, falling as low as —40°. Unskilled relief labor was employed throughout, gangs changing each week. On an average each man secured one week's employment in three. An average of 57 men per day were employed throughout. The ground varied in nature from a heavy gumbo to grey clay carrying a stratum of heavy gravel. All the work was carried out under the supervision of the city engineering staff.

The contract price, based on summer conditions and skilled labor, was $25,008.89, while the cost to the city, under the most unfavorable climatic and labor conditions, was $26,795.63. This sum includes all clerical work, supervision, insurance of men, rentals of tools, and maintenance of the sewer for six months after the completion of the work.

The writer doubts if there was 50 per cent. efficiency from the men employed in comparison with that of a regular laborer, as the men were recruited from all trades, and were entirely unfitted and unaccustomed to such work.

Table II.—Manholes and Catch Basins.

	No.	Vertical feet.	Total cost.	Unit cost.	Cost per vertical foot. With covers.	Without covers.
Manholes—Concrete	25	206	$1,710.37	$68.41	$8.30	$4.45
Brick	4	48	395.70	98.92	8.24	5.74
Catch Basins—Concrete	44	249	1,425.32	32.40	5.73	3.69

Materials—Sand, $1.80; gravel, $2.30; crushed stone, $3.30 per cubic yard. Cement, 75 cents per bag F.O.B. the job. Labor, 25 cents per hour.

The laying of storm sewers was let by contract in August, 1914, but owing to the outbreak of the European war at that time the contract was cancelled, and nothing further was done until the end of November, when, owing to the acuteness of the unemployed situation, the city council resolved to carry out the work themselves with unemployed labor. Construction was started in the beginning of December and prosecuted to completion early in March of the following year.

TRANSFERABLE LIFT SPAN FOR BRIDGE.

A lift span bridge with some unusual features is described in the Engineering Record for November 27th, 1915. Over the Arkansas River, at Pine Bluff, Ark., a bridge was recently completed in the design of which provision was made for a shifting river channel by using a lift span and five other truss spans of identical design to make possible the future transfer of the towers to lift any span desired. There is also to be noted the use of counterweight chains of special design instead of the usual wire cables, and the adoption of a folding cast-iron counterweight to control the balance of the lift span and chains. The bridge, which is a combined railway and highway structure, is approximately 3,010 feet long, with 1,610 feet of steel structure and 1,400 feet of timber trestle. The steel section consists of seven riveted spans, six of which are 239 feet 4 inches centre to centre of end pins and one 149 feet 7 inches long. The channel of the river is liable to shift at any time. At another bridge, a few miles below Pine Bluff, the channel shifted from one side of the river to the other, necessitating the construction of a new swing span, so that the bridge now has two swing spans. It was therefore considered desirable in this case to use a type of construction such that the movable span could be shifted to any part of the bridge in case of a change of location of the channel. The spans were accordingly made all alike and provided with all arrangements for attaching the lifting and control mechanisms to any one of the equal spans. The weight of the chains is balanced by disks of cast iron so arranged that they are picked up by the counterweight as it rises, thus adding to its weight to compensate for the otherwise unbalanced length of chain.

PRESENT SCOPE FOR PRACTICAL WORK IN IMPROVING CANADIAN CITIES.

THE objects and scope of the recently organized Civic Improvement League were presented to our readers in *The Canadian Engineer* for December 2nd, 1915. A conference of the League was held in Ottawa on January 20th, at which provincial and Dominion representatives were appointed as follows:

Provincial Representatives.—Ontario: Mr. G. Frank Beer, Toronto; Quebec: Hon. J. J. Guerin, President Montreal Civic Improvement League; Manitoba: Mr. W. Sanford Evans; Saskatchewan: Professor Oliver; Alberta: Commissioner Garden, Chairman Alberta Town Planning Association; British Columbia: Mr. G. R. G. Conway, M.Inst.C.E.; New Brunswick: Mr. W. F. Burditt, Chairman St. John Town Planning Commission; Nova Scotia: Mr. R. M. Hattie, Chairman Halifax Civic Improvement League; Prince Edward Island: Hon. J. A. Mathieson, Premier.

National Representatives.—Dr. J. W. Robertson, C.M.G., Mr. James White, Deputy Head, and Mr. Thomas Adams, Town Planning Adviser of the Commission of Conservation; Dr. P. H. Bryce, Hon. President of Canadian Public Health Association; Mr. J. S. Watters, President of Dominion Trades and Labor Congress; Mr. W. D. Lighthall, K.C., Secretary of the Union of Canadian Municipalities.

The chief paper presented at the latest conference was that by Mr. Thomas Adams, dealing with the present scope for practical work in improving civic conditions. Mr. Adams pointed out that between 1901 and 1911 there were created in four of the nine provinces of the Dominion an average of over 100 entirely new towns, thus illustrating the necessity for the foundations of a healthy civic structure. Concerning the scope for immediate action the paper dealt as follows:

Municipal Government and Finance and Unemployment.—The greatest need in connection with these matters is that a department of municipal affairs or a Local Government Board should be created in each province. That need arises from the fact that we require more uniformity in regard to measures which are necessary to secure (1) real and effective economies in the conduct of municipal business, (2) lower rates of interest on municipal borrowing, (3) greater efficiency in carrying out public undertakings, (4) proper auditing of municipal accounts, (5) prevention of fire and a consequent reduction in the cost of fire insurance, (6) proper control of labor difficulties during periods of slackness in employment with the least harmful results to the citizens affected during such periods, (7) enforcement of sanitary provisions, (8) avoidance of recurring mistakes in administration due to isolated local action, (9) reduction in cost of local improvement without lowering of standards of construction, (10) unifying the methods of valuing land for assessment, and other matters. We cannot overcome the defects of human nature in the personnel of councils, commissions or other bodies by legislation, but we can reduce the opportunities for bad management by setting up the right kind of machinery. At present we have a system of municipal government which is inherently bad because it lacks uniformity on the one hand and elasticity on the other hand, and to go on tinkering with it is to waste time and effort. We need a constructive policy which has for its final aim the substitution of a new system for that now in force. We need not begin by destruction or radical reform of our existing local government institutions, but we should aim at ultimately securing a final readjustment of our system so that it will attain even higher standards than those of the Mother Country where democratic local government is comparatively successful. As a beginning, we should recognize the need for apportionment of responsibility between the province and the local government unit—be it city, town or rural municipality—and make the first step in reform the setting up of a provincial department, with a cabinet minister at its head to give exclusive attention to affairs of local government. There are the beginnings of such a department in Alberta and Saskatchewan, but even in these provinces the question of giving them enlarged powers and wider scope requires consideration.

One of the most serious causes of bad sanitation is the absence of effective control over new developments just outside the boundaries of cities—in rural municipalities—and until we have a uniform sanitary standard for all urban growth whether within the city or just over its borders we will continue to have unhealthy conditions. With regard to the question of the fixing of values of land for purposes of assessment we have a position at present in many cities which contains all the elements of ultimate financial disaster unless we make an early attempt to regulate it. Bondholders frequently apply to government departments for statistics to enable them to judge of the soundness of investments in city bonds and they show a nervousness and lack of confidence in making these investments which is caused by our careless methods and is not justified by any lack of real stability in our institutions. That there is need for some stocktaking and re-appraisement of values is indicated by the fact that in more than one province we have an average assessment value per capita of nearly $1,800, as against about $550 in other provinces. In the largest cities and towns of Scotland the capital value of the assessed valuation is only $520 per capita, notwithstanding that vacant land is all assessed at agricultural rates, and every street along which buildings are erected has been constructed according to the best modern standards. An owner of land and improvements in a Scottish town can raise about four-fifths of this assessed valuation on mortgage, and the reader is asked to compare that with the proportion that could be raised of the assessed valuation of land in some of our cities.

The second suggestion under the head of municipal government is that we should ask the census department of the government to take up the question of municipal statistics. We have no satisfactory system of collecting statistics regarding municipal undertakings and finance. We collect many statistics without any apparent object in view, some of little real value because they are incomplete, and others useless because the reason for collecting them has ceased to exist. With our growing towns and steadily increasing municipal expenditure we urgently need a collection of municipal and vital statistics prepared with certain definite objects in view and we should draw the attention of the Dominion Government to this need and appoint a committee of expert municipal men to confer and make recommendations to the department concerned. Here the need for co-operation is between the (1) federal government, (2) the province, and (3) the city or town.

Town Planning, Housing and Public Health.—In regard to town planning, we have the excellent example of Nova Scotia, which has created a precedent for effective legislation dealing with this subject. The Commission of Conservation has issued a draft Act, which has been circulated among members of this conference. This draft slightly enlarges on the Nova Scotia Act, but does not differ from it in any of its material sense. Its purpose is to secure the proper regulation and control of the use and development of land for all kinds of building purposes; the term "town planning" very imperfectly indicates the

comprehensive character and real significance of the measure. Its main provisions may be summarized as follows:

(1) It is considered desirable for the working of the Act that there should be a department of municipal affairs in each province, but this is not essential, as the duties may be assigned to another department. Under the department there should be a comptroller for each province, devoting himself specially to town planning. He should keep a plan of the whole province, showing the main arterial thoroughfares which, in the opinion of the highway commissioners or minister of highways, are desirable for purposes of main road communication. In each locality there has to be a local town planning board, consisting of three members of the council and two outside ratepayers, but, if desired, the work can be done by the local authority itself, and the draft altered accordingly to secure this. The local board would have the engineering officer or other qualified person as its executive officer.

(2) This gives certain powers and duties to the local board to approve all new development and to require plans and particulars of all sub-divisions and laying out of streets to be submitted in accordance with certain procedure. The Board may require that main thoroughfares shall be 100 feet wide. Agreements may be entered into with owners permitting streets to be of less width than 66 feet where land is given by such owners for streets wider than 66 feet. Arrangements may be made for adjusting and altering boundaries and effecting changes of land already sub-divided and local boards in adjoining areas require to co-operate in regard to sub-division affecting land near to their boundaries.

(3) Town planning schemes or by-laws may be prepared for the general object of securing proper sanitary and hygienic conditions, amenity and convenience in connection with the lay-out of land. What is meant here by a set of by-laws is practically a partial town-planning scheme. Such partial schemes are compulsory and are adaptable for rural areas and small towns. The more comprehensive scheme is most suitable for large cities, and is optional. In other respects this part of the Act follows in general principle the successful British Act of 1909. Schemes and by-laws would deal with building lines, width of streets, limiting number of separate family dwelling houses to the acre, prescribing the area of any lot which can be built upon, prescribing the setting aside of areas for residential, manufacturing and other purposes, prohibiting noxious trades and structures injurious to amenity, etc.

Powers of individuals to defeat the work of a board or to indulge in speculation in expectation of improvements being carried out will be reduced to a minimum. The provincial department may prepare a scheme or by-laws if the local board fails to do so and there is strong enough local representation in favor of it being done. The local authority must provide enough money to meet the reasonable requirements of a local board to prepare a scheme or by-laws but has the option to refuse funds to carry out the provisions of either. It is necessary to give the local authority power to approve or disapprove large expenditures in executing the scheme, but it is equally necessary for the effective working of the Act that the local board should be provided with the limited amount to prepare its scheme or set of by-laws.

This is the briefest possible summary of the draft Act which will require careful study to master its details. The need for such an Act is apparent; our present method of developing land is discredited; we are creating new slum conditions in our suburban areas which are as bad as those in old centres, although they are less necessary because they are capable of being controlled by regulation; unhealthy and feverish speculation in land is the result of unbridled license in carrying out its development. Therefore, I urge that this conference should consider the desirability of recommending the provincial governments to pass legislation along the lines of the Act framed by the Commission of Conservation at the earliest moment.

The housing question requires consideration, but it is difficult to deal with it in the form of a general recommendation. The Commission of Conservation is undertaking a special study with a view to making recommendations for new legislation to the provincial governments. The writer's view is that it is desirable to suspend judgment on the housing question until this report is complete, but that the Dominion council of the league, when formed, should be asked to appoint a special committee to collect statistics and information regarding housing conditions in the different provinces.

Public health is a matter which is being well taken care of in most of the provinces. Our machinery to deal with this is fairly up-to-date. There is need, however, for more accurate and more comprehensive statistics on public health matters and something might be done to-day to indicate the strength of this need.

Immigration and Development After the War.—With regard to immigration we have a question on which experience is the best guide. It is intimately connected with our civic problems and requires consideration from the point of view of the municipality as well as that of the Dominion and province. Whether or not we should pass a resolution suggesting methods and principles which should be adopted in making a more careful selection of immigrants, and whether or not it is possible to devise a method which will encourage a greater amount of settlement in agricultural areas is a matter we should discuss.

To support the passing of town-planning legislation and the setting up of departments of municipal affairs will be one of the most effective steps to secure safeguards for civic development after the war. There is need, however, for having a constructive policy in regard to future settlement of agricultural land, particularly in connection with the return of soldiers and possible immigration of the future. We want to urge a policy which will enable us to have (1) less length of roads in rural areas, but better and more conveniently planned roads; (2) more accessibility between good areas of land and means of transportation; (3) co-operation and facilities for education and social intercourse; (4) facilities and assistance in creating rural industries in small towns and villages and the other things which are necessary in combination to secure the successful settlement of land. These things are not beyond our reach, but they require us to pay the price demanded *ab initio*, in nearly every successful enterprise. Painstaking investigation must be made, carefully prepared schemes thought out; and when our studies are completed and sound schemes prepared it will probably then be found essential for government support to be given to start the schemes, both in the form of some financial credit and in the form of administrative energy. Some definite recommendation might be made by this conference which may influence the provincial governments to deal with the problem, and be a help to the Commission of Conservation and the Economic and Development Commission in studying and recommending action in the future.

Maps.—There are other matters of importance to be considered. For instance, the writer agrees with Mr. Nelles, of the Geodetic Survey Department, that we must have better maps of our Canadian towns and cities* be-

*See "The Mapping of Canadian Cities," by Douglas H. Nelles, in *The Canadian Engineer* for Jan. [illegible] and [illegible], 191[illegible]

fore we can get the best results in planning and improving our cities and towns, also that if these maps are to be economically prepared we must look for help in their preparation to the federal and provincial governments. Let us urge the importance of this matter on the attention of the authorities concerned. There are the questions connected with child welfare, more scientific methods of distributing public charity, the question of dealing with the feeble minded, of promoting the right kind of technical education to suit our needs and others of a cognate kind.

We must be careful not to dissipate our energies over too wide a field, although we can do much by organization to so arrange and allot our work that we can include every civic activity within the scope of our organization by delegating the work to special committees.

There is need for an International Institute similar to the Agricultural Institute at Rome, to collect municipal statistics all over the world and place them at the disposal of all cities and towns. The writer hopes that the Civic Improvement League will inaugurate a movement to secure the establishment of such an institute.

VICTORIA INNER HARBOR IMPROVEMENTS.

THE 9th annual report of the Inner Harbor Association summarizes the vast amount of improvement work that has been done during the past year or is now in progress in connection with the harbor scheme. The report is, in part, as follows:—

In the upper harbor, or basin, a large portion of the bottom has now been dredged to 20 feet deep at low water. The large rock about the middle of the basin will be removed after the works are completed in the lower harbor.

The channel leading to the inner harbor is now considerably wider than formerly and forms an improvement that will be greatly appreciated by all steamships frequenting the port. The Dominion Government dredges and rock drills are engaged continuously, day and night, in deepening and widening this channel on the northern side, and the operations will be continued until the water is deep enough and wide enough to accommodate without danger ships of much larger capacity than those at present using the inner harbor.

The lower harbor generally, where dredging can be done, is now 20 feet deep at low water. The rock on the western side of the entrance (off Behrens Island) has been removed; the rocks off Shoal Point, on the eastern side of the channel, have been cut back about 200 feet, thus widening the channel considerably and straightening out a very difficult turn. This is being further widened as opportunity offers.

The northern side of the channel, between Songhees Point and Pelly Island, and eastwards to Behrens Island, is gradually being straightened, in accordance with the original scheme. The southern side of Pelly Island, and the immense mass of rock contiguous, is gradually being removed, and by the end of March will be fairly straightened out to line, widening the channel about 120 feet. The removal of Songhees Rock (west of Songhees Point at the eastern approach to the northwest passage) will shortly be undertaken, and a commencement of the removal of the material (mostly packed clay) forming the bottom of the proposed northwest passage, will be made, giving a navigable channel 300 feet wide, free from rock. This work will be proceeded with during the intervals when the dredges are not engaged in the removal of the rock broken up by the drilling plant. The work to the north of Pelly Island may be looked upon as preliminary to the eventual removal of the whole of the rock in that locality.

The Narrows between Songhees and Laurel Point have been widened about 75 feet by the removal of rock, etc., at the northern side.

To the southeast of Songhees Point the rocks have been cut back to 16 and 20 feet deep at low water. It is proposed to remove the remainder of the triangle to the railway bridge as the work proceeds inwards. All movable material has been dredged from the eastern side of this triangle and the channel, as far as the railway bridge, has been widened about 150 feet.

The general trend of the works of improvement in the inner harbor has been the gradual removal of all impediments to navigation south of a line drawn westward from Songhees Point to Pelly Island, produced westward towards Behrens Island, as laid down on our original plan and this system has been steadily pursued.

The rock blasted by the drilling plant, or broken up by the Lobnitz, is immediately removed by one of the dredges in close attendance upon these machines, and the bottom kept clear, as far as circumstances permit.

The total amount of rock, clay, gravel and sand removed from the bottom of the harbor during the year 1915 has been approximately 420,000 cubic yards, of which total about 36,000 yards were rock blasted out by the drilling plant or broken up by the Lobnitz rock-breaker. The total outlay on these works during the year has been about $230,000.

The above refers, as stated, to the inner harbor work, and does not cover the extensive work under way on the outer harbor, docks and breakwater. An important part of the latter work completed during the year is the formation of a turning basin, some 21,000 superficial feet in area, dredged to 30 feet at low water, for the manoeuvring of ocean vessels leaving port.

About two-thirds of the length of the breakwater is now above high-water level and the structure is meeting all expectations in securing quiet water under the most stormy circumstances, not only at the new piers under construction, but also preventing the breaking of heavy seas over Rithet's southern wharf. The work on the two piers is making rapid progress. Already nine of the 3,000-ton caissons are in place. At present the work on the piers is all under water and it will be another year before they assume visible shape and proportions.

The total outlay to date on the breakwater has been about $1,400,000 and on the new piers about $740,000.

MEAN SEA LEVEL FOR RAILWAY PROFILES.

General Order No. 157 of the Board of Railway Commissioners for Canada requires that on and after February 1st, 1916, all profiles submitted by railway companies subject to the jurisdiction of the Board, which commence at, terminate at or intersect with any of the lines listed in "Altitudes in Canada," edited by James White, assistant to the chairman and deputy head of the Commission of Conservation, shall be based upon mean sea level as provided in that publication. This includes those which touch tide water and are not listed in "Altitudes in Canada." The Canadian Pacific, Canadian Northern, Grand Trunk Pacific and Grand Trunk Railway Companies have all consented to the proposal.

The annual meeting of the Manitoba Good Roads Association will be held on February 14th.

WATER POWERS IN THE PORCUPINE AREA OF NORTHERN ONTARIO.

OF interest in connection with the increased mining activity in the Porcupine gold area is a consideration of its water power resources. In *The Canadian Engineer* for December 16, 1915, the subject was discussed in an abstract from the 1914 report of Mr. Thos. W. Gibson, Deputy Minister of Mines for Ontario. The following notes are from the Ontario Bureau of Mines' report on the Porcupine gold area, which contains an appendix prepared by W. R. Rogers, topographer of the Bureau, and dealing with the subject of water powers within the area.

Mr. Rogers states that during early mining operations in Northern Ontario, steam power from wood fuel is used in the preliminary working of prospects, but that, as development proceeds, timber in the immediate neighborhood is soon exhausted, and then either coal or hydro-electric energy must be resorted to for power purposes.

All the hydro-electric power furnished the Porcupine camp comes from two plants situated on the Mattagami River, a tributary of the Moose flowing into James Bay. The location of the power plants with respect to the mining area is indicated on the accompanying sketch map. Both of these were formerly independent plants, but now are controlled and operated by the Northern Canada Power Company, Limited. The two plants are provided with interswitching facilities, so that they work continually in parallel. The new company has expended a great deal of money in new construction, replacements, and betterments, so as to guarantee to power users continuous and satisfactory service.

The first development was that at Sandy Falls, six miles northwest of Timmins, which is the terminus of the Porcupine branch of the Timiskaming and Northern Ontario Railway. Power was available from this development in June, 1911, and a saw mill operated on the east bank of the Mattagami River before the mines were ready to use electric energy—a unique experience in a new mining camp.

Two units are installed in the power house with a total capacity of 2,500 h.p. It is the intention to install other units, doubling the capacity. The effective head is 35 feet. During the summer of 1913 extensive improvements to the plant were undertaken. The timber dam is now replaced by a concrete structure, from which water is carried to the power house by a 9-foot wood stave and an 8-foot steel penstock.

A continuous record of the flow of the river has not been kept, but several measurements have been made during low-water periods in different years and meter records are as follows:—

January 20, 1910	1,654 cubic feet per second
March, 1910	517 cubic feet per second
March 25, 1912	633 cubic feet per second
March 25-26, 1914	500 cubic feet per second

A meter record taken July 4, 1911, at Cypress Falls, some miles down the river, gave a discharge of 3,351 cubic feet per second. Here the drainage area is estimated at 4,500 square miles, whereas at Sandy Falls it is only 2,500 square miles. Reducing the reading on this basis would give a flow of 1,862 cubic feet per second at Sandy Falls on the above mentioned date.

From the available records it will be seen that 500 cubic feet per second may be assumed at the extreme low-water natural discharge. This is equivalent to only 1,600 h.p., while the total capacity of the present installation is 2,500 h.p. Consequently controlled storage must be resorted to for increasing the minimum flow. This is now provided for above Wawaitin Falls.

The other power house, situated at Wawaitin Falls, is distant 11 miles southwest of the town of Timmins. This plant was not ready to supply power until the autumn of 1912. From the dam at the foot of Kenogamisee Lake, an expansion of the Mattagami River, there is an open canal 1,200 feet long from which water is led through two 9-foot wood stave penstocks, each 1,500 feet in length, to a surge tank, 40 feet in diameter, on the crest of the hill overlooking the power house. From the surge tank two 8-foot steel penstocks, each 1,300 feet long, lead to the power house. The operating head is 125 feet. At present two units are installed with a total capacity of 7,000 h.p. Canal and head works, however, are arranged so that the power house can be extended and two more units added, thereby doubling the capacity.

Fig. 1.—Showing Location of Power Plants on the Mattagami River at Wawaitin and Sandy Falls, also Transmission Lines to the Porcupine Mines

Meter records available at this point under natural flow are as follows:—

March, 1910	366 cubic feet per second
July 15, 1911	792 cubic feet per second
March 16-30, 1913	195 to 240 cubic feet per second
March 25-26, 1914	354 cubic feet per second

The Cypress Fall record for July 4, 1911, corrected for a drainage area of 1,000 square miles instead of 4,500, would give a natural flow of 745 cubic feet per second. This record corresponds closely with that for July 15, 1911. Assuming 200 cubic feet per second as the minimum natural flow, the horse-power resulting would be only 30 per cent. of the present capacity of the power plant, hence the necessity for storage.

From the records, it would appear that a run-off coefficient of 0.2 cubic feet per second per square mile of drainage area may be taken as representing the minimum flow of the Mattagami River under natural conditions.

Storage.—High-water periods in Northern Ontario are at the time of the spring break-up, and to a much less

extent during the late autumn, when rains are usually fairly abundant. February and March have been the months when water becomes scanty, particularly in those winters when the usual thaws did not occur. How to provide for low-water periods without reliance upon auxiliary steam plants is a problem that can be solved only when abundant storage is possible. The experience of the power plants on the Mattagami River has very definitely established this fact.

Pondage may be considered as the close-at-hand storage of water immediately available for use in the turbines. It is a necessary precaution in Ontario water powers in order to provide against ice troubles as well as to meet local fluctuations in power needs during the day. Three distinct types of ice are met with: surface or sheet, anchor, and frazil. The first, in addition to restricting the area of the channels, is liable to cause jams in the spring, cutting off the water supply or raising the tail water with a consequent loss of head. Anchor ice frequently rises in large masses, often carrying boulders and soil which are liable to damage the ice racks. Frazil ice, in the shape of needles, forms in rapids when the temperature is slightly below the freezing point. These needles or crystals gather in lumps and adhere readily to any surface with which they come in contact. Trouble from these latter sources is avoided when a long stretch of still water exists above the power house, while surface ice trouble is largely overcome by proper dam construction.

Prior to the erection of the large plant of the Abitibi Power and Paper Company, at Iroquois Falls, on the Abitibi River (see *The Canadian Engineer*, July 1st, 1915), the two power plants on the Mattagami River were the only ones in Ontario on the James Bay slope. Consequently, their experience is of value to other power developers and users. The James Bay drainage basin is very conservatively estimated as capable of developing 1,500,000 h.p., or 30 per cent. of the total potential water power of the Province of Ontario.

When the meter record of March 25-26, 1914, was taken at Wawaitin the total flow was 518 second-feet, of which 164 was drawn from a storage basin of 33,000 acre-feet. During the winter of 1914-15 a new dam was built at Kenogamisee Falls, increasing the storage capacity to 100,000 acre-feet. This reservoir should be ample to supplement the flow at low-water periods. Kenogamisee Lake, the original reservoir, is shallow, and the water available is considerably lessened in late winter by a two-foot covering of ice.

Floods and Forests in Relation to Storage.—Floods are reduced in magnitude and stream flow rendered more constant where the drainage basin at headwaters is forested. For the most part, Northern Ontario is a forested area, but, where such is not the case, reforesting, particularly at the sources of streams, as an aid to reliance upon storage reservoirs, seems a necessary precaution of the future in order to prevent disastrous floods, and to equalize as much as possible the stream flow throughout the year. Floods may do little damage at present except to power installations, so the ideal conditions will not receive much attention until some future time when a shortage of power makes their consideration urgent.

Sometimes the topography of drainage areas precludes the possibility of providing large storage reservoirs. In Northern Ontario, water storage above the natural high-water mark on streams and lakes is not desirable, as it results in killing the timber along the banks and shores, giving the country a most desolate and deserted appearance. The concensus of opinion favors storage at or near the sources of streams, thereby preventing a combination of conditions which usually occasion disastrous floods in the areas adjacent to the lower stretches of the river.

In the particular case of the Mattagami River, the present storage not only helps the power plants already in operation, but will improve the conditions for future developments farther down the river. At eight different points down stream where surveys have been made, the farthest of which is only 75 miles north of the Transcontinental Railway, it is possible to develop a total of 149,235 h.p. under natural conditions. In this estimate the coefficient used for minimum low-water discharge is 0.3 c.f.s. per square mile of drainage area. Records at Sandy and Wawaitin Falls indicate that 0.2 is the proper coefficient. This would reduce the estimate of undeveloped energy on the Mattagami River to 100,000 h.p. Storage facilities, with the exception of those already mentioned in connection with the Wawaitin development, are very meagre, and consequently the river cannot be described as well-regulated in its natural condition.

Power Storage.—In his statistical review, referred to above, T. W. Gibson points out some of the power difficulties that have been experienced, and refers briefly to the auxiliary steam plants that have been provided by the larger mines to meet emergencies resulting from electric power shortage.

During the winter of 1911-12, owing to extreme low water, there was a shortage of power for operating the Porcupine mines, but since that date the Wawaitin Falls development has been completed and the Sandy Falls plant improved and enlarged. Despite this increase of capacity there was again a decided shortage of water during the winter of 1914-15 that was not relieved until the second week in April, 1915, thereby seriously interrupting the work of the mines and curtailing the gold production.

In the Porcupine camp, provision has been made, to the extent of about 2,500 h.p., to meet periods of power interruption. This is notably the case at the Hollinger mine, where two new compressors, driven by synchronous motors, have been arranged so that they can be turned into steam engines and the motors used as electric generators supplying current for general use around the mine and mill or for driving other compressors.

Power Costs.—In the Cobalt silver camp where the Northern Ontario Light and Power Company operates, and also at Porcupine, where the Northern Canada Power Company supplies electric energy, a flat rate of $50 per horse-power per annum has obtained until recently. Many of the contracts are expiring and the power companies are proposing to introduce new schedules with a sliding scale of rates depending on the amount of power consumed and the load factor. In some cases the new rates work out at a higher figure than the old. The largest consumer in the Cobalt camp is the Dominion Reduction Company, which requires over 500 h.p. for operating its plant. The Dome and Hollinger mines are the largest consumers in the Porcupine camp. At the present time the former uses about 2,000 and the latter 3,500 electrical horse-power.

CHANGE OF NAME.

The International Acheson Graphite Company of Niagara Falls, N.Y., has changed its name, and hereafter will be known as Acheson Graphite Company.

Some tests of the weight of freshly cut woods have just been made by the Laurentide Company, of Grand Mere, P.Q. They show that brown ash weighs 50.26 pounds per cubic foot, yellow birch 61.40 pounds, white birch 55.02 pounds, elm 71.31 pounds, and sugar maple 73.38 pounds.

CONSTRUCTION NEWS

WATER, SEWAGE AND REFUSE.

Chatham, Ont.—A 2-inch water main will be laid to supply the new sugar factory site for construction purposes. About 1,500 feet of pipe will be required. W. G. Merritt, City Clerk.

▲—**Collingwood, Ont.**—Tenders will be received by Hugh A. Currie, Chairman of the Collingwood Water and Light Commission, up to 8 p.m., on Wednesday, March 1st, for the following works:—(1) Steel water tower. (2) Foundation for steel water tower. (3) Pumping machinery, comprising one motor-driven unit of 800 imperial gallons capacity. (4) Pump well and connections. Plans and specifications may be seen at the office of Chipman & Power, Engineers, 204 Mail Building, Toronto, or at the Water and Light Office, Collingwood.

Niagara-on-the-Lake, Ont.—An 8-inch tile sewer will likely be constructed on Prideaux St.

Ottawa, Ont.—The city council intends to undertake the following works as local improvements: A 9-inch tile pipe sewer in Bullman St., from Parkdale Ave. to the west limit of Lot No. 894 Bullman St. North, at an estimated cost of $1,460.85; a 12-inch tile pipe sewer in Scott St., from Pinehurst Ave. to the west limit Lot No. 891 Scott St. South. Estimated cost, $3,238.40. Norman H. H. Lett, City Clerk.

Stratford, Ont.—The board of works recommended the construction of a sewer on Nelson Street, from Walnut Street to lot 246; also improved storm drainage on Mornington Street. from Waterloo Street to James Street, and from the intersection of Birmingham and Youngs Street to the Erie Creek. A. B. Manson, City Engineer.

+—**Toronto, Ont.**—Contracts for sewer construction, awarded by the board of control, were as follows: Cawthra Ave., Lloyd Ave. to C.P.R., to R. C. HARRIS, Commissioner of Works, at $4,074; Connolly St., Laughton Ave. to Campbell Ave., to W. E. TAYLOR, at $1,198.

Toronto, Ont.—The Provincial Board of Health has approved of sewer extensions at St. Catharines.

Winnipeg, Man.—Estimates of the cost of nine-inch and 18-inch sewer accommodation for the military in the exhibition grounds will be submitted to the board of control by W. P. Brereton, City Engineer.

Winnipeg, Man.—Plans are being prepared for the construction of watermains to the proposed Institute for the Deaf and Blind.

Winnipeg, Man.—The Jefferson Ave. Joint Sewer Committee has given orders that the sewer must be built to the west side of the C.P.R. Winnipeg Beach line by March 15.

LIGHT, HEAT AND POWER.

Amherstburg, Ont.—A new street lighting system will be installed at a cost of $2,582. G. E. Pulford, Clerk.

Dereham Tp., Ont.—The township council proposes to install light and power systems. Alex. Bell, Mount Elgin, Ont., Clerk.

East Williams Tp., Ont.—Estimates on the construction of a hydro-electric line from Granton to Arkona will be secured by the township council. W. McCallum, Nairn, Ont., Clerk.

Galt, Ont.—The city will purchase an electric motor for the pumping station. Jos. McCartney, City Clerk.

Hamilton, Ont.—Tenders will be received up to 5 p.m. on Monday, February 21st, for the removal and re-erection of existing pumps, motors and electrical equipment at the Gage Ave. sewage pumping station. Plans and specifications may be seen at the office of A. F. Macallum, City Engineer, City Hall.

London, Ont.—The Canadian Pacific Railway Telephone Co., Montreal, proposes to run a new copper line between London and Toronto.

McGillivray Tp., Ont.—Estimates are being prepared by the Hydro Commission on the cost of a line through McGillivray from Lucan to Grand Bend. J. D. Drummond, Ailsa Craig, Clerk.

New Toronto, Ont.—Tenders will be received up to 4 p.m. on Friday, February 18th, for the supply of a 500-gallon turbine pump together with motor. Engineers, James, Loudon & Hertzberg, Excelsior Life Building, Toronto.

Niagara Falls, Ont.—The Ontario Power Company will spend $3,000,000 to build a third pipeline and install new units to increase by one-third the amount of power the company at present can generate. The work will require two years to complete.

▲—**Ottawa, Ont.**—Tenders will be received up to 12 o'clock noon, March 1st, for the construction of a pumping station and electric sub-station on Lemieux Island; the manufacture, delivery and installation of main piping, valves and specials; heating and plumbing, all for the above station. Plans and specifications may be seen at the office of the Engineer, John B. McRae, 310 Booth Building, Ottawa.

+—**Ottawa, Ont.**—The following contracts have been awarded by the city council: Supply of one motor, SHEPHERD & CAMERON, Queen St.; two pumps, MUSSENS, LIMITED, Montreal; boiler, OTTAWA BOILER & STEEL WORKS, 135 Broad St.

+—**St. Thomas, Ont.**—The local hydro-electric commission awarded the contract for two 750 k.v.a. transformers to the CANADIAN GENERAL ELECTRIC COMPANY, LIMITED, of Toronto, for $6,650.

Tisdale Tp., Ont.—The township council will purchase a fire pump estimated to cost about $5,000. W. H. Wilson, South Porcupine, Ont., Clerk.

BRIDGES, ROADS AND STREETS.

Edmonton, Alta.—Mr. J. D. McArthur, of Winnipeg, President of the Edmonton, Dunvegan and British Columbia Railway, states that plans are being prepared for a large steel bridge over Peace River at Peace River Crossing. Estimated cost, $750,000.

Frontenac County, Ont.—The good roads committee was authorized by the county council to appoint a commission to act in conjunction with a commission to be appointed by the Lieutenant-Governor in Council to lay out and designate a suburban area of county roads adjacent to the city of Kingston.

Hamilton, Ont.—Plans for the bridge over the Valley Inn, to be used in connection with the entrance of the Toronto-Hamilton highway to the city, will shortly be considered by the board of control. It is estimated that the bridge will cost $250,000.

Merritton, Ont.—The town council is considering the laying of pavement on a portion of Merritt St. F. Rutherford, 24 Queen St., St. Catharines, Engineer.

Montreal, Que.—Tenders will be received by the Board of Commissioners, City Hall, up to noon, Thursday, February 24th, for the supply and delivery of refined asphalt. Specifications may be obtained at the office of the Superintendent of Purchases and Sales, and all necessary information will be given at the office of Paul E. Mercier, City Engineer.

West Toronto, Ont.—The Good Roads Commission has recommended that Dundas Street, from Runnymede Road to Lambton Hill, be paved with asphalt. Estimated cost, $12,000.

York County, Ont.—The county council passed a by-law to borrow $78,000 to finance the York road system until the June session of the council, when debentures will be issued. Of the total $12,000 is for maintenance, $35,000 for construction, and the balance to meet liabilities already incurred.

York County, Ont.—York county council has decided to construct 210 miles of highways at a cost of between $700,000 and $800,000. E. A. James, 57 Adelaide St. E., Engineer.

FACTORIES AND LARGE BUILDINGS.

+—Arnprior, Ont.—Contract awarded by the Department of Militia and Defence, Ottawa, to MAURICE SULLIVAN, of this town, for the erection of a drill hall.

Buckingham, Que.—The Alexandra Hotel, recently destroyed by fire, will be rebuilt at once. Estimated cost, $20,000. J. A. Bernardin, Owner.

Cottam, Ont.—The Imperial Bank proposes to establish a branch here. W. A. Clark, Essex, Ont., Manager.

Davidson, Sask.—The Bank of British North America was destroyed by fire recently. Loss, $4,[illegible]

Ditton, Que.—The School Board is considering the erection of three schools, estimated to cost $4,400. Secretary, Tancrede Halle, Ditton.

Edmonton, Alta.—The three-story plant of the Emery Manufacturing Company was destroyed by fire last week. The loss is $100,000.

Haileybury, Ont.—The hotel owned by Otto Knapp has been entirely destroyed by fire. Loss, $90,000, insurance $62,000. Owner will probably rebuild in the spring.

Hamilton, Ont.—As a result of a conference between the board of control and the hospital board, it was decided to erect a nurses' home in connection with the Mountain Hospital at a cost of $30,000. S. H. Kent, City Clerk.

+—Hamilton, Ont.—Contract awarded to DAWSON & WEST for repairs to the building on Catharine Street North, of Kent, Garvin & Co. Estimated cost, $2,800.

Hamilton, Ont.—The Grand Trunk Railway Co., Montreal, will erect a new station on North Ferguson Ave., to replace the old structure at the Corner of King Street and Ferguson Avenue.

+—Hespeler, Ont.—A. B. Jardine & Company's plant, destroyed by fire last week, will be rebuilt. The contract for the carpenter work has been let to PRESTIEN & BARTLES, and for the masonry work to GRILL BROS.

Loco, B.C.—The Imperial Oil Company, Limited, 404 Abbott Street, Vancouver, contemplates the erection of an office building and club house, at an estimated cost of $18,000. Tenders will be called later.

London, Ont.—Plans are being prepared for enlarging the plant of the Parnell Steam Baking Company, and installing new machinery. Estimated cost, $50,000. E. Parnell, Manager.

Moncton, N.B.—Tenders will be received by George Morton, Secretary, School Trustees, McQuade P.O., Moncton, N.B., up to February 17th, for the construction of a schoolhouse. Plans and specifications may be seen at the Times Office, Moncton, or on application to Jas. McQuade, McQuade P.O.

Montreal, Que.—According to a statement made by J. H. Rainville, M.P., a large factory will likely be built here for the manufacture of cutlery.

Oakville, Ont.—Wallace, Chapman & Marshall will establish a factory here for the manufacture of boxes, etc.

Ontario.—Votes by the Dominion Government for public buildings in Ontario, mostly revotes or to complete buildings already begun, include the following:—Barrie, drill hall, $15,000; Berlin, public building, $50,000; Brantford, new drill hall, $75,000; Brussels, public building, $22,500; Burford, public building, $10,000; Burk's Falls, public building, $20,000; Campbellford, public building, $16,000; Cannington, public building, $8,000; Cobourg, new public building, $25,000; Copper Cliff, public building, $15,000; Cornwall, public improvements, $3,000; Dunnville, public building, $20,000; Durham, public building, $24,000; Elmira, public building, $5,000; Exeter, public building, $15,000; Forest, public building, $20,000; Fort Frances, public building, $25,000; Fort William, customs house and examining warehouse, $15,000; Fort William, drill hall, $30,000; Galt, drill hall, $6,000; Georgetown, public building, $20,000; Gore Bay, public building, $5,000; Gravenhurst, public building, $20,000; Hamilton, 7 public buildings, enlargements and improvements, $47,000; Hamilton, Postal Station "B," $35,000; Hespeler, public building, $22,000; Huntsville, public building, $20,000; Ingersoll, drill hall, $25,000; Kenora, drill hall, $20,000; Kingston, R.M.C., covered drill hall, $15,000; Kingston, ordnance stores building, $10,000; Kingsville, public buildings, $20,000; Lindsay, public building improvements, $7,000; Listowel, drill hall, $3,000; London, armory, to enlarge site, $50,000; London, postoffice, $95,000; London, Customs House improvements, $7,000; Meaford, public building, $10,000; Millbrook, public building, $20,000; Milverton, public building, $5,000; Morrisburg, public building, $20,000; Napanee, drill hall, $10,000; New Liskeard, public building, $20,000; New Hamburg, public building, $10,000; Oakville, public building, $5,000; Orangeville, public building, alterations, additions, etc., $9,000; Ottawa, departmental buildings, fittings, etc., $50,000; Ottawa, Customs building, $530,000; Ottawa, new drill hall, $50,000; Ottawa, Parliament buildings, improvements, $30,000; Owen Sound, drill hall, $25,000; Palmerston, public building, $19,000; Parry Sound, public building, $20,000; Pembroke, drill hall, $4,000; Penetanguishene, public building, $7,000; Perth, public building, $25,000; Peterborough, new public building, $47,000; Petrolea, public building, improvements, etc., $2,000; Picton, postoffice addition, etc., $11,000; Port Stanley, public building, $5,000; Sault Ste. Marie, drill hall, $25,000; Southampton, public building, $20,000; Stratford, public building, alterations, and improvements, $20,000; Sturgeon Falls, public building, $7,000; St. Catharines, public building, repairs to roof, etc., $3,000; Sydenham, public building, $5,000; Walkerville, public building, $5,000; Wallaceburg, public building, $25,000; Watford, public building, $20,000; West Lorne, public building, $20,000; Weston, public building, $10,000; Wiarton, public building, $19,000; Windsor, drill hall, extension, $25,000.

Ottawa, Ont.—Fire completely destroyed the manufacturing establishment of the Grant, Holden and Graham Co., Limited, on Albert St., recently. Estimated loss, $20,000.

Prince Rupert, B.C.—Plans are being made by T. M. Michaels and F. J. Burling, for the construction of a woodworking plant in this city. A sawmill will also be erected in the early spring at Port Simpson, B.C.

Regina, Sask.—Plans are being prepared for a four-room school.

Richelieu Village, Que.—The erection of a school is contemplated by the School Board. Estimated cost, $3,000. Secretary, J. C. Bashaw.

Smith's Falls, Ont.—The Elgin Ward School was totally destroyed by fire last week.

St. John's, Nfld.—W. F. Coaker, of St. John's, contemplates the establishment of a shipbuilding plant at Catalina, Nfld.

Stratford, Ont.—A. J. Bates, of the McConkey-Bates Co., proposes to build a factory for the manufacture of corrugated iron.

Sydney, N.S.—The Knights of Columbus contemplate the erection of a building estimated to cost between $20,000 and $30,000.

+—Toronto, Ont.—Contract awarded to the DOMINION BRIDGE CO. for alterations to the premises of the Standard Sanitary Mfg. Co., 55 Richmond St. E. Estimated cost, $1,000.

Toronto, Ont.—The factory of the Hamilton Carburetter Company on Queen Street will be enlarged.

Toronto, Ont.—The Board of Education is considering the construction of an Industrial Farm School to consist of buildings each capable of accommodating fifty inmates. Estimated cost, between $25,000 and $50,000 each.

Vancouver, B.C.—Mr. Alex. Pantages, of Seattle, has announced that work will start shortly on the erection of a theatre on Hastings St., estimated to cost $250,000.

+—Vancouver, B.C.—The work of constructing a $60,000 addition to the plant of the American Can Co., Railway St., will be carried out by the DOMINION CONSTRUCTION COMPANY.

West Garafraxa Tp., Ont.—The trustees of School Sections Nos. 4 and 10 are considering the erection of schools. Secretaries, W. J. Philip, R.R. No. 3, Arthur, Ont., and J. A. Spence, R.R. No. 3, Arthur, Ont.

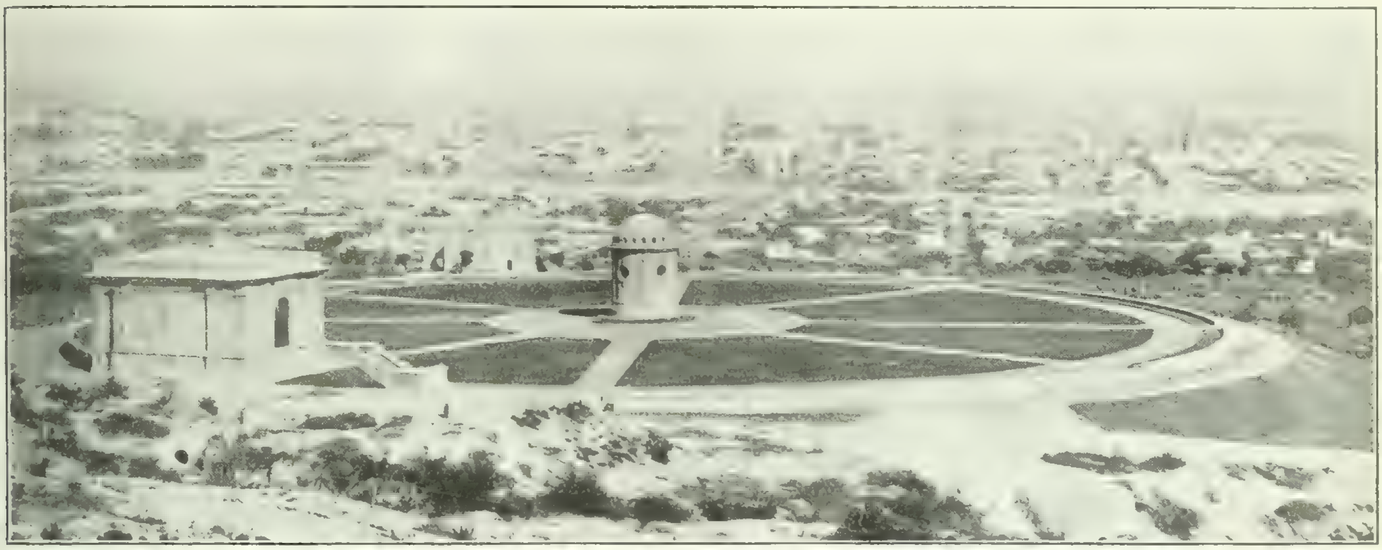
Woodstock, Ont.—The Standard Wire Fence & Tube Company will erect a new warehouse, estimated to cost $1,000.

ADDITIONAL CONSTRUCTION NEWS will be found on page 58.

THE ENGINEER AND STANDARDS OF BEAUTY.*

By G. R. G. Conway, M.Can.Soc.C.E.,
Consulting Engineer, Toronto.

THE work of the engineer touches every phase of our national and civic life, and the influence of engineering structures upon the community life of the people is of great national importance. In new countries we cannot expect in the early pioneer days that much consideration will be given to the finer details of designing. To open up great tracts of unpeopled territory, railways must be built as rapidly and as cheaply as possible, and there is always a fitness and simplicity in the temporary structures that are erected with the available local materials that appeal to us with pleasure because in this pioneer stage there is no time for the consideration of how such structures will look. To create electrical energy, waterfalls and rivers must be harnessed, and to accomplish this economically dams of the cheapest materials are thrown across streams and rivers for storage purposes. To develop highways, bridges must be built, and these, too, in the early days consist of a few logs cut down on the site and secured after the primitive fashion of the pioneer in all ages. As the new country develops, however, and this is true all over the American continent, wealth is created on the foundations laid by the sturdy pioneers of our race, and the small structural works have grown into gigantic engineering enterprises serving, it may be, millions of people, and because of such service daily influencing their comfort and well-being. The engineer is then brought face to face with the idea of permanence in his structures, and in the interests of economical administration it is necessary for him so to design his structures that the annual cost of maintenance is reduced to a minimum. The temporary trestles and bridges of the early railroads are replaced by steel, masonry, concrete or earthen structures. Old timber crib dams make way for permanent structures of concrete or earth work. Simple timber railway stations become massive structures of brick or stone, and so on throughout the whole range of the engineer's province, the new structures taking the place of the old bear most emphatically the stamp of permanence. If, then, we are building structures that are to last for generations, is it not worth while to design them so that the Canadians of future generations, looking back upon the great works being carried out to-day, and the greater works which we anticipate to-morrow, will admire and appreciate the early work of the 20th century as we admire and appreciate the great works executed at the beginning of the 19th century in Great Britain and France? Or, to go further back, as we ourselves admire the work of the Romans—that wonderful race, great in art, great in science, and famous for immortal laws, who "builded better than they knew," and who, with true and noble colonizing instincts, scattered over two continents wonderful engineering works that we can marvel at even if we cannot emulate them.

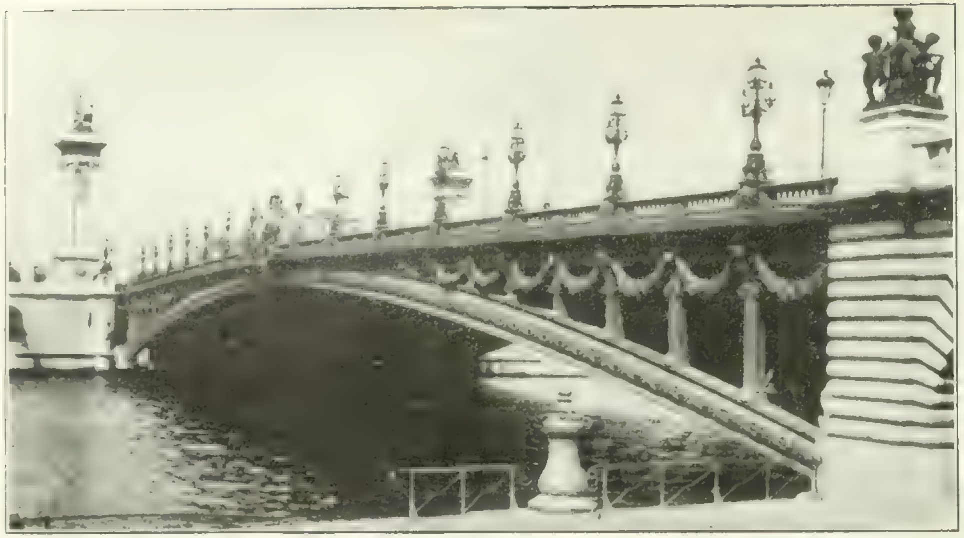


Service Reservoir, Monterey, Mexico, Showing a Simple Architectural Treatment of Valve Houses and Layout of Roof in Grass Plots.

The standards of beauty are enlarged with the growth of knowledge. Many of the works of the ancients are of great beauty and will always remain beautiful, but beauty and the appreciation of beauty are inherent in ourselves. The creation of beautiful structures can only be attained by a full and true knowledge of the kind of materials used, and by certain subtle distinctions born of integrity of purpose and refinement in handling those materials. Ruskin's well-known aphorism, in which he defines architecture as "the art which so disposes and adorns the edifices raised by man, for whatsoever uses, that the sight of them may contribute to his mental health, power and pleasure," has a meaning for us as engineers.

This is an age of specialization. That, of course, is an idle platitude, for no man can say to-day, as Lord Bacon said, "I will take all knowledge to be my province." Even the most versatile engineer can attempt to master but one branch of his profession. In our own Society we have among those directing the "great sources of power in Nature for the use and convenience of man," engineers engaged in bridge design, railroads, canals, hydraulics, water supply, and sewerage; electrical, mining, municipal mechanical, and chemical engineers, but in olden days the sister professions of engineering and architecture were practised in many cases by the same individual. Roman engineers, designers of the Claudian Aqueduct and the Pont du Gard, produced great engineering works which are among the finest architectural remains of that great

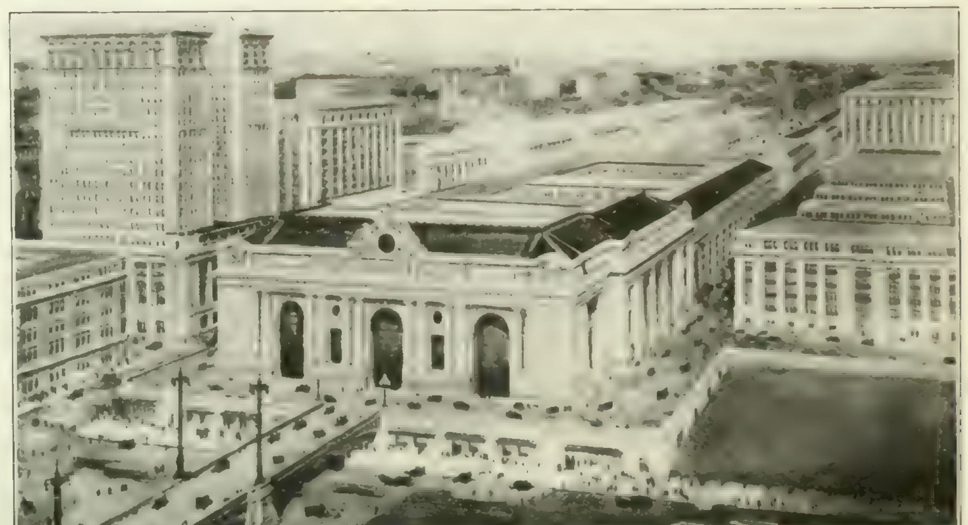
*From an illustrated address before the Ottawa Branch of the Canadian Society of Civil Engineers, January 21st, 1916.



Example of the Collaboration of Engineers, Architects and Sculptors, Pont Alexandre, Paris.

Detail of Parapets on the Pont Alexandre, Illustrated in the Opposite View.

Main Dam of the Ashokan Reservoir, Brown, Station, N.Y. A Structure that Requires no Ornaments but Care in Designing Parapet.



Grand Central Railway Station, New York. Example of Collaboration of Engineer and Architect.

race, and in the Renaissance period were not such artists as Michael Angelo, Leonard da Vinci, and Palladio great both in architecture and engineering? In mediaeval ages, bridges, churches, cathedrals and dwelling houses were designed under the supervision of the priests and clergy, but during the 16th and 17th centuries these supervisors of craftsmen became more interested in doctrinal controversies and so both architectural and engineering problems passed from their control, and the new profession of the civil engineer arose with such pioneers as Brindley, Smeaton, Telford, and Rennie.

With the development of steam and all the discoveries of modern science and engineering, the separation of the two professions became wider, but I think to-day there is a new spirit that is drawing them together again. The question, then, of the aesthetic treatment of engineering structures is to-day more fully appreciated by an enlarging circle, and it is one in which the engineer needs and desires the co-operation of the architect. This co-operation of the engineer and architect will have the effect of stimulating a healthy public interest in the need for great engineering structures being made as beautiful as possible. It has been said by a well-known engineer that if two designs are submitted to a board of directors, the one beautiful and the other ugly, the directors will always choose the ugly one, but this is untrue to-day, and many great corporations are setting a worthy example in encouraging the co-operation of the engineer and the architect.

Why should not even the humblest railway station be a beautiful object? We no longer believe in Ruskin's fierce denunciation of railway stations, and in these days of constant travel the comfort and beauty of well designed railway terminals are a delight to travelling man. Why cannot we have beautiful designs for the buildings and chimneys of steam power plants, for a water tower, for all our bridges, for service reservoirs, and valve houses? We should, though, in every case, let these structures speak for themselves and express by their design their meaning, stating plainly, without pretension, what they represent. We do not want a railway terminal to look like a temple for the worship of Minerva, nor a steam plant chimney to resemble Cleopatra's needle.

Probably most of the discussion upon this subject has arisen in connection with the design of bridges, and the writer has noted with pleasure recently the influential engineering press stimulating thought in this direction. Let us, therefore, examine first the evolutionary changes in bridge design by referring to some old and modern types of bridges. The earliest method of crossing a river was, perhaps, by stepping stones, by logs thrown across the stream or, where the span was wide, by a bridge of boats. It is, though, outside the scope of this paper to discuss the origin of the several types upon which all modern bridges are designed. Many beautiful bridges have been designed in wood. We have records of some of the earliest that combined great ingenuity with beauty, and to-day in Switzerland and Japan are many notable examples.

For two thousand years the engineer has been able to make masonry bridges beautiful, and although his opportunities in Canada for constructing such bridges are few, a study of the older designs is of great assistance in dealing with reinforced concrete structures which are in our country taking the place of the cut stone structures of Europe.

In the Pont du Gard, built by Agrippa, the son-in-law of Augustus, in 19 B.C., there is a grand combination produced by the form and proportion of the arches, and the varied effect of dressed and undressed masonry. In this structure, as well as in the Claudian Aqueduct, and the aqueduct at Tarragona, in Spain, the engineering skill is remarkable, proving that the Romans were highly skilled in mechanics and hydraulics. In these structures we see the harmony of science and art, twin sisters who should never be separated, and the result stands to-day a triumph of fine building.

In the bridge of Augustus, at Rimini, the piers are very massive, equal in thickness to one-half of the arch openings. There still remain traces of decoration on the key stones, and the ruined cornice indicates that the bridge was one of great beauty. Judging from its massive proportions, it is probable that over the piers were elaborate architectural details combined with noble statuary. Structurally it is excellent engineering, and even now, after the lapse of nearly 2,000 years, can be seen the fine workmanship of the old masons.

In the Renaissance period in Italy we could select many types for illustration of beautiful bridges which were erected by architects and engineers. One of the best-known, and one which well repays careful study, is Bartholomew Ammanati's famous bridge, which was rebuilt in 1566-1569, called the Pont della Trinata, over the Arno, at Florence. Ammanati's genius as an architect and sculptor is well known, and in this bridge we find careful study given to the engineering details that go to make up a successful structure. There are three spans, the centre 90 ft. 10 ins., and the two side spans 87 ft. 7 ins. The arches are two parabolic curves meeting at a centre with a slight angle which is obscured by an ornamental escutcheon. The arch ring is very heavily moulded, and the spandril panelled, a method which requires very careful treatment to prevent the scale of the design being lost.

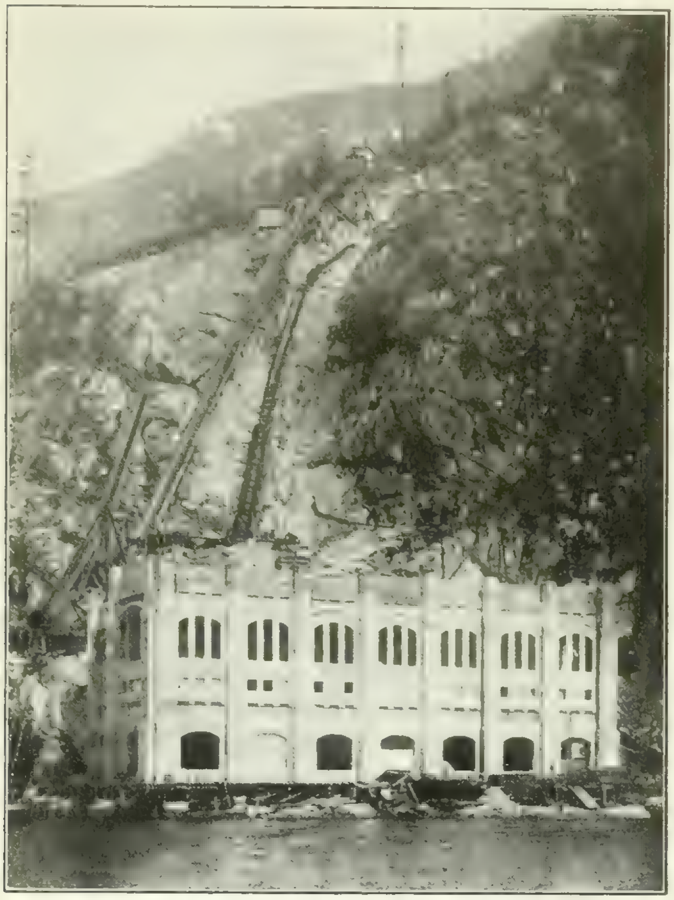
During mediaeval times many beautiful bridges were built in Great Britain which are standing to-day more beautiful than ever with the "golden stain of time" upon them. The Bridge of Dee is an excellent example. Of particular worthiness of note is the treatment of the under side of the arch by ribbing so as to economize material and produce at the same time delightful effects of light and shade. It might be suggested that a similar treatment is possible in an economical design of a reinforced concrete bridge.

[Mr. Conway similarly called attention to the early masonry bridges of France, and to the London, Waterloo, Aberdeen and Grosvenor masonry bridges of Great Britain. Over 40 lantern views of bridges were shown, the selection bringing out in an able manner the aesthetic features of each. As lack of space forbids the presentation here of these illustrations, portions of Mr. Conway's discussion relating specially to certain examples are necessarily omitted.—Editor.]

Iron and Steel Structures.—It is when we come to consider the modern development of bridge building, and the introduction of iron and steel, that the aesthetic problems assume a different character from those of simple masonry structures. The development of the use of iron and steel in bridge building has been, to use Herbert Spencer's line of progress in organic evolution, "from simplicity to complexity of structure, and from obscure complexity to a defined simplicity of function." It is this simplicity of function which is the prevailing note of all well-designed steel structures. Michael Angelo maintained that to an architect a knowledge of anatomy was essential. Can we not also say that to those who examine iron and steel structures from the purely aesthetic viewpoint a knowledge of the anatomy of a bridge is necessary, and an understanding of the relationship and

the functions of all its separate parts? Metal bridges include the majority of all long-spanned arches. The longest single masonry span in existence is 295 feet, and bridges of reinforced concrete have already been constructed with spans up to 325 feet. The longest single steel span, as you all know, is that of the Quebec bridge, which is 1,800 feet. In such structures, therefore, the addition of ornament would be entirely false and foreign to the fundamental principle of their design, and its application, if done at all, could only be carried out consistently by a great increase of weight and sacrifice of economy.

The standard of aesthetic criticism to be adopted must depend, therefore, upon whether the most suitable application of the material used has been made, and when it is possible to select an optional design the choice must lie with the most beautiful outline consistent with economy.



Power House No. 2, Lake Buntzen, B.C.

The sweeping condemnation of all iron and steel structures that has sometimes been made by artists and architects is due to a false and unfair appeal to standards which, however true they may be when applied to masonry bridges, cannot be applied to structures which have forms and functions of an entirely different nature.

The first consideration, therefore, in designing all engineering structures after the questions of strength and stability have been satisfied, is that the form of the structure should be determined essentially by the material of which it is composed, and should not copy in some strange, fantastic form in some of its details the design of older forms of architectural ornament.

In a discussion which took place some sixteen or seventeen years ago at the Institution of Civil Engineers, Professor Pite said that as a practical designer he would like earnestly and heartily to press home the fact that artistic simplicity would be achieved by disassociating from the mind all architectural phrasology, all architectural ornament, all architectural traditions, such fantasies as the curve and compound curve lines of beauty, and by aiming in metal bridge building at exactly the same beauty of workmanship, beauty of economy of material, beauty of accomplishment that please the mind in any form of mechanical effort. In that way engineers would keep clear of the changing whims of artistic fashion, keep clear in metal of the traditions of an architectural art of stone, of the traditions of an architectural art in wood, and work out in iron with its different qualities and stresses an aesthetic style based on the absolute scientific necessities of engineering practice which would, without doubt, afford infinite satisfaction to generations to come.

The earliest attempt to build an iron bridge was made at Lyons in 1755. The arches were actually cast, but the attempt was abandoned as too costly, and the real introducers of iron in bridge building were two ironmasters, Reynolds and Derby, who designed the bridge in Coalbrookdale. In this bridge there is a curious treatment of metal work which the early designers, under the influence of mediaeval bridges, adopted. At a later date, at the beginning of the 19th century, when Rennie and Telford were making use of the new material for longer span bridges than they had hitherto adopted, and where the metal bridge was combined with masonry abutments, careful attention was given to the architectural treatment of the masonry portion of the work.

In such bridges as the Garabit viaduct in the south of France, Niagara Falls bridge, Brooklyn Suspension bridge, and the bridge over the Zambesi River, the most exacting demands are satisfied. These bridges please the eye because of their sense of fitness to the site and the work they have to perform.

Probably the cantilever bridge has been, more than any other form, subjected to severe criticism from the aesthetic point of view. The famous Forth bridge, which perhaps represents the highest expression of engineering skill yet reached, roused a storm of aesthetic criticism, which was to be expected against a structure few people could understand. William Morris, a man for whom many of us have the greatest admiration, and one who spent his life successfully in striving to make the England he loved so well a more beautiful place than he found it, went down to Edinburgh when the bridge was completed and said there never would be an architecture in iron, every improvement in machinery being uglier and uglier, until they reached the supremest specimen of all ugliness—the Forth bridge.

The next evening at the Edinburgh Philosophical Society, Sir Benjamin Baker appeared on the scene and replied that he expressed a doubt if Mr. Morris had the faintest knowledge of the duties which the great structure had to perform, and he could not judge of the impression it made upon the minds of those who, having that knowledge, could appreciate the direction of the lines of stress and the fitness of the several members to resist the forces. Probably Mr. Morris would judge the beauty of the design from the same standpoint whether for a bridge a mile long or for a silver chimney ornament. It was impossible for anyone to pronounce authoritatively on the beauty of an object without knowing its functions. The simple columns of the Parthenon were beautiful where they stood, but had they taken one and bored a hole through its axis and used it as the funnel of an Atlantic liner, it would, to his mind, cease to be beautiful, but, of course, Mr. Morris could think otherwise. He had been asked why the under side of the bridge had not been made

a true arc instead of polygonal in form, and his reply was that to have made it so would have materialized a falsehood. The Forth bridge was not an arch and it said so for itself. No one would admire bent columns on an architectural facade, or a beam tricked out to look like an arch, but that was really what the suggestion of his artistic friends amounted to, though they did not see it, being ignorant of the principles on which the Forth bridge was constructed. The object had been to so arrange the leading lines of the structure as to convey an idea of strength and stability. This in such a structure seemed to be at once the truest and highest art. We must admit that the engineer was right. On the other hand, the view of another artist, Alfred Waterhouse, R.A., is interesting.

nation of Gothic architecture with a steel structure destroys the sense of fitness and robs the bridge of true beauty by giving it an architectural character of a by-gone age when such bridges could not have been erected.

In many simple bridges constructed in Canada to-day to open highways in inaccessible places, a note of simplicity has often been successfully struck. As an example of this the suspension bridge over the Bulkley River at Hagwillgate, B.C., with the simple treatment of the suspension piers is entirely satisfactory.

An example of the most perfect collaboration of the architect and engineer appears, in the writer's opinion, in the Pont Alexandre bridge at Paris (illustrated on another page). This is a three-hinge steel arch, and the whole

Example of a Masonry Structure where Careful Attention Has Been Given to the Architectural Details of the Design. Craig Goch Dam for Birmingham Water Supply.

Writing to Sir John Fowler after the bridge was completed, he said: "The simple directness of purpose with which it does its work is splendid, and invests your vast monument with a kind of beauty of its own, differing though it certainly does from all other beautiful things I have seen."

In the design of the Tower bridge there is a great departure from those principles which Sir Benjamin Baker advocated when discussing the design of the Forth bridge. The site of this bridge, in close proximity to the Tower of London, influenced its design, and although the claim has been made that this bridge expresses perfectly the collaboration of the architect and engineer, one feels that the Gothic masonry is entirely out of place. The combi-

structure is one of the most beautiful that has been built at any time. It is the work of two engineers, two architects, and two sculptors, working in collaboration.

During recent years there has been a marked advance in the design of reinforced concrete structures, and the pages of the engineering press fully illustrate many notable designs that appeal to us by their simplicity. Among those that are notable is the Langwise Viaduct,* carrying the Churarosa Railway in Switzerland; the Walnut Lane bridge, Philadelphia, and a score of others.

Dams.—In the construction of dams for the storage of water for city water supplies, power purposes, and irri-

*See *The Canadian Engineer* for October 14th, 1915.

gation works, many opportunities occur for the collaboration of architect and engineer. When the drawings were being prepared in the office of James Mansergh for those wonderful dams in the Elan Valley for the supply of water for Birmingham, Mr. Mansergh asked Professor Pite and Sir Alfred East, the one an architect, the other an artist, to study the site and make suggestions to him upon their architectural treatment. The result is magnificent, and no one who has seen those works since their completion can fail to be impressed with the beautiful designs and their fitness with the surroundings. In this case, and also in the case of the Vyrnwy Dam for the storage of water for Liverpool, the utilitarian work of the engineer has created a beauty spot accessible to tourists. The large works recently carried out by the Irrigation and Reclamation Departments of the United States include a number of great dams which, together with the work of the Boards

Intake Tower, Coquitlam Lake, New Westminster Waterworks, B.C.

of Water Supply for New York City and Boston, set examples that can with advantage be followed in many other places. With many dams, such as the simple reinforced concrete type, no attempt at architectural decoration beyond perhaps a carefully designed parapet is required. In the Bassano dam,† which is a very massive structure, it is to be regretted that the gate-houses have been designed in the domestic half-timbered style—a style which seems singularly out of place when forming an integral part of what is a magnificent concrete structure. The influence of the architect is not always satisfactory, even when his collaboration is sought by the engineer. As an illustration of this, the reader is reminded of the building of the Assouan Dam in Egypt, and of some remarks made by Sir Benjamin Baker, the engineer, to the effect that after the drawings of the dam had been completed they had been turned over to an architectural department, and the architect, having returned from Egypt saturated with Egyptian temples, had covered the design with details of Egyptian architecture. Sir Benjamin Baker told the contractors who were tendering upon the work to take no notice of the architectural ornament as he did not want the dam to imitate a temple built four or five thousand years before. When the dam was in progress, tourists of all professions—artists, architects, and engineers—all of whom had been dosed with Egyptian temples themselves and had their ideas of how a great dam built across the Nile should look—visited the works. Sir Benjamin Baker told the contractors to have full size models made of the suggested adornment and placed on some of the completed parts of the dam so as to make the suggestors ashamed of themselves. These models frightened Lord Cromer who told Sir Benjamin that he could have all the money he needed to make the dam safe, but that he was not going to spend a hundred and fifty thousand or two hundred thousand pounds for architectural details. Sir Benjamin told Lord Cromer there was no intention of doing so, that he had put up the models to show how the ornament would look in strong sun-light with deep shadows. The result was that everyone agreed that what might look all right and proper on paper for a limited length would be madness applied to a cornice 2½ miles long, and here perhaps is an instance where collaboration with architects not understanding the character of the dam would have led the engineer astray in designing such a structure.

Power Houses.—Canada, in proportion to her population, has in recent years made enormous strides in the development of water power, and from the Atlantic to the Pacific great developments have taken place. In the design of water power plants there is a great opportunity for the engineer to dignify his work by paying more attention to the design of power house buildings and their surroundings. Often these power plants are situated amidst magnificent scenery, and the only blots upon the landscape are the buildings and pipe lines. There are, of course, notable exceptions such as the power houses at Niagara (on the Canadian side) where an attempt has been made to harmonize these plants in such a way as not to detract from the beauty of the Falls. But too little consideration has been given so far by power companies to the erection of buildings that will be a delight to the public. The Water Power Branch of the Department of the Interior has recently taken a great interest in this particular matter, and has been encouraging the idea by offering prizes for the best designs for proposed power houses on the Bow and Winnipeg Rivers. This is an excellent step forward, and I think when plans are forwarded to the Government Department for approval the question of the design of power house exteriors should also be considered by the responsible officials. That the architect can successfully make a beautiful power house, even if constructed of reinforced concrete without other materials, is shown in the design of Lake Buntzen Power House No. 2 (illustrated herewith). This plant has been built upon a site visible for seven or eight miles on an arm of the sea that is a favorite yachting resort, and the design is an imposing one from every point of view, the simple lines and massive proportions harmonizing with the precipitous mountains in the background. This matter is largely in the hands of the engineer who is not often hampered in his desire to produce a fine building, and in many cases by a careful study of proportions and the economical use of material, no extra cost will be incurred.

†See *The Canadian Engineer* for January 1st, 1914, and September 30th, 1915.

Municipal Water Supplies.—In municipal water supplies many opportunities occur on a small scale for graceful treatment of such works as service reservoirs, water towers, aqueducts, etc. In Europe and many places in the United States there are numbers of fine works showing that municipalities are becoming proud of their property, and while they are seeking to make them permanent they are also attempting to make them beautiful.

Railway Terminals.—In the design of railway terminals to-day it is the generally accepted practice for great railway corporations to employ architects to collaborate with the engineering staff, but often the architectural style adopted is a severely classic one which does not seem to the engineer to be an expression of 20th century railway progress. Perhaps some day, under the influence of the engineer, the architect will free himself from the traditions of archaeology and classic architecture, and give us a railway architecture that will be an expression of our modern spirit. Examples of the collaboration of the two professions may be seen in the Grand Central and Pennsyvlania railway terminals of New York, the Union terminal at Washington, D.C., and the collaboration of the architect and engineer has also been carried out in many of the terminals of the three great transcontinental railways in Canada.

Modern Steel Frame and Reinforced Concrete Buildings.—In the design of modern steel frame and reinforced concrete buildings the modern engineer and architect in Canada have in collaboration one of the most magnificent opportunities of evolving an architectural treatment of their structures unhampered by European traditions. We may perhaps criticize the architect for his neglect of a proper study of the main principles involved in the design of great buildings as he is in danger of becoming merely the adorner or decorator of structures for which he is not primarily responsible. We feel that the ornament on a building should accentuate and add to the beauty of its proportions, and in the complete design the architect and engineer should be in closest sympathy. To the engineer it seems incongruous to pile row on row of classic orders and details one on top of the other in the facade of a modern steel structure when there is an opportunity of maintaining the leading lines of the construction. May we not ask, when we look around and examine many decorated steel structures in Canada and the United States, if the architects are not too much dominated by modern French classic influences. A very simple and beautiful exterior treatment of a reinforced concrete building is seen in the new Birks Building in Vancouver, and here it will be noticed that the architects have not attempted to hide the structural proportions of the building. In New York, in spite of the Government's insistence that all new public buildings shall be of classic design, we find in the Woolworth Building (the highest in the world) a free treatment of Gothic details in terra cotta that does not hide or destroy the proportions of the engineer's steel design. In this building we see a very fine example of the engineer and architect in closest sympathy. No architect or engineer alone could have produced it because the building, from foundation to tower, involved some of the most difficult problems in engineering design. The building is one that fascinates the onlooker and must be regarded as very successful from the architectural point of view. The writer is, however, aware that artists have denounced the architectural treatment and have called the building an eye-sore, but it would be interesting to know what alternative method of treatment they would propose for a building of that character. It seems to the engineer that the architect in adorning a steel frame building should accentuate its proportions if they are true. If they are not true no ornament will help to make the building beautiful, and engineers and architects alike should remember Pope's criticism of the artist and poet:

> "Poets heap virtues, painters gems at will,
> And hide by ornament their want of skill."

and guard against the temptation to adorn with architectural details what might possibly be faulty construction.

Town Planning.—In another field of activity there is great scope for the co-operation of the two professions, namely, that of town planning. The civic idea is a very ancient one and has always dominated the progressive spirit of a great race, and in the creation of beautiful cities this cannot be accomplished by the landscape gardener or architect alone, but by the co-operation of engineers engaged in many different branches of the profession, and it would be well if we as engineers would cordially support and assist the efforts of the new Civic Improvement League in Canada so as to make our cities healthier and more beautiful in the future.

Our citizens should take a keener interest in their great public structures, and aspire to something beyond mere utility. Before we can expect them to do so, we must consider our own attitude and endeavor to educate the public so that the standards of taste and ideals are raised until Art in its highest expression pervades every part of our civic and national life. We need a truer education of the public, and of those chief citizens whom the people, in their collective wisdom, send to represent them in council chambers and in the legislature. As a result of such education we ourselves will create structures which will stand as permanent monuments of a people that endeavor not only to produce great works of utility, but works of beauty, in the service of man.

BETTER RAILWAY EQUIPMENT NEEDED.

Speaking at the annual meeting in Chicago on February 4th, of the American Electric Railway Association, while on the subject of safety on American railroads, Senator Oscar W. Underwood, of Alabama referred as follows to the fact that there are at least 10 employees killed or injured on American lines to one on the railroads of Great Britain.

"It can not be truthfully said the engineers who constructed these roads have builded them with less ability than the engineers who constructed the English roads. It can not be said that our iron and steel, our timber and rock are not as good building material as that which is found in the British Isles. It can not be said that the men who sit at the throttle, or watch the signal tower are less capable, sober and alert than the men who occupy similar positions in a foreign land. Then why should we face conditions that endanger human life, and make a serious charge on transportation, that in the end the public must bear? To my mind it is clear that the dangers involved in our railroad system are almost entirely due to the lack of proper transportation facilities. We endeavor to run trains over a single track where the needs of business require double tracks. We load our freight on weak and defective cars where new cars should long ago have taken their place. We rely on antiquated methods for the movement of our trains when our tracks should be provided with the latest and best signal devices. In fact it cannot be denied that to adopt modern methods and provide proper facilities for transportation would be true economy in the end."

THE USE OF INFILTRATION GALLERIES IN WATER SUPPLY.

THE water supply system of Brooklyn, N.Y., includes two infiltration galleries with a combined length of about six miles, in addition to some 25 driven well stations, collecting from 975 wells varying in depth from 30 to 325 ft. The system was described in a paper read before the New England Waterworks Association last September, and some interesting discussion was subsequently presented concerning the operation of infiltration galleries, in view of the successful use of them in Brooklyn. We refer to the following remarks by Alexander Potter, a New York consulting engineer, which appeared in the Journal of the Association for December:

The procuring of water supplies by means of infiltration galleries is not commonly resorted to. Even where the use of infiltration galleries promises to yield good results, engineers often hesitate to make use of them because of the many failures recorded, the causes for which either are not understood or when understood have not been brought to the attention of the engineering profession.

The proper design of an infiltration gallery should not be at all difficult, for the process which takes place in an infiltration gallery is duplicated in nature by the diffused seepage of the underground waters into surface streams. This ground-water seepage maintains the flow in surface streams long after the direct effects of the rainfall have ceased. The fundamental laws governing the ground-water flow of surface streams are fairly well understood and apply with slight modifications to infiltration galleries. They may be stated as follows:

1. The ground-water stream flow is fixed and limited to the surplus underground waters accumulating and stored in the valley.

2. The rate of seepage varies with the transverse hydraulic slope of the ground-water table and the porosity of the material through which the ground water flows.

3. When the hydraulic slope is not steep enough to discharge the surplus ground waters as fast as they collect in the valley, the ground-water table rises until equilibrium is established, and vice versâ if opposite conditions exist.

4. Except as affected by the seasonal changes of the rising and lowering of the ground-water level, the ground-water stream flow is constant.

There is no reason why the seepage of ground-water into an infiltration gallery under proper conditions should not be equally as dependable as the identical natural process of ground-water seepage into surface streams.

An infiltration gallery may derive its supply of water from two distinct sources: A supply derived by intercepting the surface underground waters which were under natural conditions joining the surface waters by diffused seepage, and a supply derived by infiltration from bodies of surface waters adjacent to the infiltration gallery. It appears that many infiltration galleries derive by far the larger portion of their supply from the second source. A carefully made scientific investigation will, in nearly every case, reveal within quite narrow limits the quantity of water available for an infiltration gallery from the two sources above mentioned, and as long as the draft does not exceed the available supply there is no reason why the yield of a properly designed infiltration gallery should gradually decrease with time, as is only too often the case. The recorded failures of infiltration galleries can, in the writer's opinion, be largely attributed to the erroneous assumption that a pipe laid below water level with open joints or perforations and surrounded by a porous material will continue to deliver the volume of flow developed when first constructed, ignoring entirely the fundamental law of supply and demand.

This is not true with infiltration galleries constructed on the floor of an impervious strata intercepting the transverse ground-water flow in a pervious strata of coarse sand immediately above. Under such conditions, infiltration galleries have been very successful. A typical example of such a gallery is the one constructed at Munich.

Under conditions other than that just stated, and where the supply appears to be adequate, there is often noted a gradual breaking down of the infiltration gallery, apparently due to the silting up of the filter media immediately surrounding the gallery. Under the natural conditions of ground-water seepage into surface streams, no such silting appears to take place, and when such silting up occurs in connection with an infiltration gallery, it can only be due to the peculiar ground-water conditions set up by construction of the gallery. The writer believes that the silting phenomena are primarily due to the high velocities of the ground water through the filter media immediately adjacent to the gallery, velocities so great that the finer particles of soil are transported to the gallery, gradually clogging the interstices in the filtering media and the gallery proper. This phenomenon of clogging is aggravated by the lowering of the ground-water level in the vicinity of the filter gallery below the top of the gallery. For a definite yield, as the wetted perimeter of the gallery decreases, the entrance velocity increases in inverse proportion. To attempt, therefore, to force an infiltration gallery to the extent of lowering the ground-water table below the top of the gallery, will tend to increase the danger from clogging and materially shorten the life of the infiltration gallery, especially when constructed in the finer sands.

With tubular wells, the question of high entrance velocity in the filtering media surrounding the well screen is not of equal importance; wells are comparatively short-lived, and when clogging does occur it can be remedied by back-flushing or other known methods. No such remedies are available for clogged infiltration galleries. When properly designed so that the yield of the gallery does not exceed the supply available from the surplus underground waters and the supply derived by infiltration from a nearby body of surface water, and the entrance velocities are sufficiently low so as not to transport the finest soil particle, the useful life of the infiltration gallery should be practically unlimited.

The yield from an infiltration gallery constructed in the finer sands should be automatically controlled so that it cannot exceed a certain predetermined amount, in order to prevent the lowering of the ground-water plane below the top of the gallery, so as to keep the entrance velocities within safe limits. This condition can best be secured by restricting the flow from the gallery to an amount which will keep the gallery constantly full of water for its entire length.

In many cases the requirements as outlined herein will for a given yield call for the construction of much longer lines of infiltration galleries, constructed in finer sands than has been the practice in the past, so that in many instances other methods of supply will be found to be more economical. Throughout the country, however, deposits of gravel and sand exist in the valleys of rivers and along lakes and seacoasts, in which infiltration galleries can be economically constructed to yield adequate supplies either from the surplus underground waters or from the water derived by infiltration from adjacent natural and artificial bodies of water, or from both sources. The

(Continued on page 272.)

BRITISH COLUMBIA HARBORS.

An illustrated article in *The Canadian Engineer* for January 13, 1915, described the new Grand Trunk Pacific Railway dry dock and terminal at Prince Rupert, B.C. A few notes relating to the harbors and facilities along the Pacific Coast of Canada may not be amiss.

Prince Rupert, with a population of 6,000, is 583 miles north of Vancouver on the British Columbia coast line. It has a broad, open harbor 16 miles in length with an average width of 1½ miles and an average depth of 26 fathoms. Besides the Grand Trunk Pacific Railway wharf there is a Provincial Government wharf 600 ft. long and also an open dock 375 ft. long and a dry dock 120 ft. in length, all of which are equipped with storage warehouses.

The Imperial Oil Company is constructing a 5-tank wharf and oil dock with pumping station and complete facilities.

The industries of Prince Rupert comprise seven cold storage concerns, a large fishing industry, two small boat-building concerns and a number of saw and shingle mills.

The New Westminster harbor is situated about 12 miles from salt water on the Fraser River. The city has a population of 20,000, and is a market centre of a rich agricultural district with a population of over 70,000. Salmon fishing is its big industry, there being over thirty canneries in the neighborhood. The city is also the centre of the lumber industry of the southern part of the province, the Fraser mills being claimed to be the largest in the world.

Vancouver, with a population of 125,000, has a harbor extending from Point Atkinson on the west to Port Moody on the east, a distance of 24 miles. It varies in depth from 28 ft. at the wharves to 200 ft. in midstream. There are many wharves, the chief owners of which are Canadian Pacific Railway, Great Northern Railway, Grand Trunk Pacific, British Columbia Sugar Refinery Co., Evans, Coleman and Evans Wharf Co., Johnson Wharf Co., New Vancouver Ferries, etc. The Dominion Government has just completed a wharf at the foot of Salisbury Drive on the south side of Burrard Inlet. This wharf has cost $1,500,000 exclusive of buildings, cranes, etc. It has a total length of 800 ft. and is 300 ft. wide with slips at either side, of 132 ft. These slips have a minimum depth of 35 ft. at low water. A similar wharf is proposed by the government for the north shore of the inlet. The Canadian Pacific Railway and the Grand Trunk Pacific have oil docks in use.

The new outer harbor at Victoria, at present under construction by the Department of Public Works, will provide approximately 10,000 ft. of berthing and will be fully equipped with most modern machinery, warehouses, etc., the cost approximating $2,300,000, exclusive of equipment. It will be one of the best harbors on the Pacific Coast. Two immense concrete piers with warehouses and excellent cargo-handling facilities are being built out into the Straits of Juan de Fuca and a railway slip will enable car ferries to load and unload at the dock. A stone breakwater with concrete blocks surmounted by a concrete wall 2,500 ft. in length will extend westward from Ogden Point. The piers will be 1,000 ft. long. The harbor comprises an area of nearly 300 acres of water, varying in depth from 30 to 80 ft. The breakwater mentioned above will effectually shelter all the piers to be constructed under present arrangements, all piers proposed for construction northward and will, in addition, protect the entrance to the inner harbor. There will be direct rail connection with the harbor from the railway terminals to be built on the Songhees reserve.

In addition to the Dominion Government docks, the Grand Trunk Pacific, the Canadian Pacific Railway and Messrs. R. P. Rithet & Co., have extensive wharves. Of the latter, one pier is 688 ft. x 100 ft., and has a shed with a floor space of 32,000 ft. It is provided with three slips on the west side and two on the east with water 33 ft. deep at low tide. Another is 1,050 ft. x 125 ft. with a shed 818 ft. long and a floor space of 39,500 ft. The depth is 35 ft. at low water.

FEDERAL GOVERNMENT EXPENDITURES IN 1916-17.

The main estimates for the fiscal year 1916-17, tabled in the House of Commons at Ottawa by Sir Thos. White, on February 3rd, indicate that it is the intention of the Government to continue the construction of public works already under way. Further, there has been provision made for a certain amount of new work. Some of the important items for new work or for work now under contract include the following:

Port Arthur and Fort William harbor improvements	$1,000,000
Quebec dry dock	1,500,000
St. John harbor improvements	1,000,000
Intercolonial Railway bridges	483,000
Halifax terminals	3,000,000
Quebec bridge	3,450,000
Hudson Bay Railway	3,000,000
National Transcontinental Railway	1,500,000
Welland Canal	4,500,000
Trent Canal	1,000,000
Toronto Harbor improvements	600,000
Toronto Customs Building	500,000
Postal Station "A," Toronto	455,000
Ottawa Customs Building	530,000

MUNICIPAL IMPROVEMENTS AT NORTH VANCOUVER.

In his report for 1915, Mr. A. R. Clucas, city engineer of North Vancouver, summarizes the following expenditures in his department: Road construction, $18,214.94; board of works general expenditure, $10,663.85; local improvements, $2,337.03; waterworks construction, $980.75; waterworks general, $5,319.34; reservoir at Rice Lake, work in progress, $10,551.44; lanes, $606.57; parks, cemeteries and boulevards, $6,392.12; making a total of $55,066.04.

INTERNATIONAL ENGINEERING CONGRESS, 1915.

The committee of management, International Engineering Congress, 1915, announces that the volume on Mechanical Engineering is ready for distribution and the members who have subscribed to this volume will soon receive it.

The other volumes will be issued as rapidly as possible. Owing to the large amount of material to be reprinted, and the thousands of copies to be bound, the work cannot be carried on with greater speed. However, it is hoped that within two months the entire set will be completed.

Members who did not send in their final selections may be disappointed in not securing all the volumes they might have had in mind, and at this date the Committee has decided to close the lists for certain volumes which have been sent to the press. It may be possible to supply members who would apply at this late hour with copies of volumes which have not gone to press.

ROAD CONSTRUCTION AND IMPROVEMENT

ABSTRACTS FROM THE PAPERS READ AT THE RECENT CONFERENCE ON ROAD CONSTRUCTION HELD IN TORONTO BY THE ONTARIO DEPARTMENT OF PUBLIC HIGHWAYS.

PAINTING AND MAINTAINING STEEL HIGHWAY BRIDGES.

By George Hogarth, O.L.S., A.M.Can.Soc.C.E.
Chief Engineer of Highways for Ontario.

THE steel bridges on our highways were built of members which had probably been unprotected and exposed to the weather for a more or less extended period. The condition of the surface of the steel before it is painted has a very important relation to the length of life of the coat of paint applied to it, and also to the length of life of the completed structure. Possibly many of the pieces of steel had been recently rolled and were new and clean and bright. Some sections may have had a slight coating of rust, while others may have been pitted, rusted and scaled due to the length of exposure. New steel, when built into a bridge, will usually provide a structure which will last longer than one built of sections already rusted and decayed. Further, the new steel presents a surface which readily takes the paint, and that surface has none of the rust which, when painted over, causes the early failure of such covering. To properly prepare the steel surface for painting, all rust must be removed by means of steel scrapers, chisels and wire brushes, so that the clean surface of the steel is exposed. In carrying out that operation considerable care and muscular exertion on the part of the workmen is necessary and unless a good inspector is present the work may be slighted and an inferior result obtained, or complete failure of the shop coat of paint may occur.

Great emphasis is to be given to the fact that all rust, dirt and grease must be thoroughly removed from the steel just before the shop coat of paint is applied since upon this foundation coat the life of the second and finishing coats depends. If the shop coat is carelessly applied over rust and scale it will disappear entirely when that scale falls away and the surface of the metal will then be exposed to further rusting.

Painting steel bridges adds to the cost of such structures, and the reasons for going to this additional expense should be investigated. The practice of painting new steel bridges is defended and justified by the fact that it is a universal custom and all bridge specifications require that paint of one kind or another be applied to the structures after they are fabricated. Painting also improves the appearance of the bridge and lengthens the life of the structure by preventing rusting and corrosion of the steel.

To develop and encourage a provincial custom of keeping steel highway bridges well and properly painted is a duty which those in authority should at once assume and efforts towards establishing a definite course of action in that respect require immediate consideration. Such frequent painting has not been carried out in the past because of the mistaken belief that a steel bridge once built will last forever. This neglect has in recent years resulted in many bridges being found to be so badly rusted that steps must be taken to replace them.

On large bridges, which are carefully and systematically looked after, painters are employed during the favorable seasons of each year and they are kept steadily at work scraping and painting the various parts of the structures. The railways of this country have millions of dollars invested in steel bridges and they insist that experienced men paint all steel structures as often as necessary. In every case the reasons given for all the care and expense are that the life of the bridge is prolonged and the structure is kept in its original good condition as long as it is carefully looked after. A bridge which is painted every four years after being built will require only five complete paintings to last 24 or 25 years, and at the end of that time it will be in good condition. Yet, the experience is that bridges built 20 and 22 years ago are to-day in a very doubtful condition, due to the rusting away of a considerable quantity of steel. The cost of a few paintings is only a fraction of the cost of any steel structure, and when at small cost the life of such structure can be prolonged indefinitely it is economy to use paint.

All experience points to the fact that steel bridges should be painted periodically. The business corporations have found it best to properly paint and maintain their steel structures and it is advisable that municipal organizations carefully consider the financing of similar work with a view to prolonging the life and improving the appearance of structures under their control.

The new bridge is painted when it is built and that covering will last probably from one to four years, depending on the condition of the surface of the steel, the quality of the paint and the care used in applying it. At the end of that time patches of paint of varying sizes have disappeared and the exposed steelwork is rusting away as rapidly as possible. A neglected bridge on a well-kept public highway is an eyesore and demands the labor of the painter in order that its appearance may be in keeping with that of the roadway.

Careful attention to the painting of steel bridges should be given from the day the structure is first completed. Semi-annual inspections in the early spring and fall should be made of all structures, and wherever small failures of the film of paint are discovered the painter should at once be ordered out to carefully scrape and repaint the exposed parts. Every four or five years the structure will require complete repainting. Immediately before the paint is applied, the steelwork must be carefully and systematically cleaned of all dirt, loose paint and rust. A complete supply of steel brushes, scrapers and chisels should be provided for the men and frequent visits to the work should be made to see that these tools are used. The structure should be painted in sections as fast as the cleaning progresses, and three coats of paint applied. In all cases ample time should be allowed between coats to enable the proper drying of the film. Weather conditions during painting have considerable influence on the life of paint, and it is advisable that the complete repainting of bridges be undertaken only during the warm, dry months of the year. Care should be taken to see that the steel is dry before commencing work in the morning and probably the best plan would be to have the men attend to other work till, say, 8.30 a.m. Actual experiments have proved that painting on wet or damp surfaces shortens the life of the paint.

For the information of the official in charge of the work, the date of painting should be stencilled on some

convenient part of the structure in order to facilitate the recording of the action of the paint during its life.

The selection of a paint for steel bridges is a problem that possibly all have been called upon to solve at one time or another. To be satisfactory, a paint must fulfil many exacting requirements which may be enumerated as follows: It must be low in price; it must be readily obtained in convenient quantities and in satisfactory containers; it must completely hide the surface of the steel in two coats; should cement itself together and stick to damp or dry metallic surfaces; should expand and contract without cracking the film; should present a hard, tough outer surface; should be impervious to water or gases; should be unaffected by sunshine, heat, frost, dew or climatic changes; should be unaffected by ordinary mechanical abrasion; should wear evenly; should fail by gradual wear and not by disintegration; should leave a good surface for repainting; should not require an unreasonable amount of skill or muscle in application; should be homogeneous; should dry properly; should not be readily ignited; should have power to absorb and remove moisture or dampness from the metal; should have properties that will prevent corrosive action of traces of water in contact with the metal and should not stimulate corrosion of the steel. In connection with the last requirement it would be well to state that paints made from certain materials have been found to slowly produce rusting of the steel in small patches.

While these requirements are numerous and apparently difficult to fulfil, it is possible to-day to purchase in any locality the necessary ingredients which, when combined, will produce a perfectly reliable paint for steel structures. There are also on the market to-day a number of ready-mixed paints which the manufacturers recommend as a protection for structural steel. For many years a red lead and linseed oil paint has been extensively used for priming and field coats for a large number of bridges. At times there has been a tendency to abandon such coverings of proven merit in favor of more modern proprietary paints, but usually, after unfavorable experience with the newer ideas, a return is made to the red lead. Where objection is made to the bright color of red lead in the finishing coat it is suggested that the third coat be darkened by the addition of lampblack. If pure lampblack is used in the final coat, the life of the paint will not be shortened.

[Mr. Hogarth exhibited four specimens of steel angle sections painted with red lead, each specimen illustrating a different degree of surface deterioration and the variation that may occur in the quality of material built into a structure, emphasizing the necessity for careful inspection.]

Maintaining Steel Highway Bridges.—A steel highway bridge requires the proper careful attention due to that class of structure. Changes are constantly occurring in various parts of its members and thorough semi-annual inspections are imperative if the structure is to continue in a safe condition for public travel.

The inspection in the spring should be undertaken with a view to ascertaining the general condition of the structure and also to lay out and decide on the manner of carrying out whatever work is to be done at the bridge during the following summer. The fall inspection should be made with a view to estimating the cost of whatever repairs may be required during the following summer.

Many instances could be cited where an inspection of a bridge has revealed a serious condition of affairs due to broken sections which, if unattended to, might result in serious damage or complete collapse of the structure. Until recently, many of the structures built were pin-connected and were provided with tension members composed of square rods with a welded eye at each end. Indifferent workmanship in forming the weld creates a weak spot which, after a few years of service, becomes apparent when the weld breaks open. If there are two bars in the member there is still sufficient strength available to carry the structure pending immediate repairs, but in no case should unnecessary chances be taken and if the inspector is in any doubt as to the ability of the structure to stand up, the best course to pursue is to close the bridge till repairs are completed. The manner in which steel sometimes breaks is very difficult to account for, and frequent inspection is the only way in which the safety of the bridge can be certified to. Steel is the same as any other commercial product and carelessness in manufacture is reflected in the action of the finished article.

The semi-annual inspections should include every portion of the bridge—the handrail, the approaches and the river channel. Attention to the condition of the approach handrails to discover loose or decayed sections is advisable. Notice boards calling the attention of fast travellers to certain laws may be in place, but are in all probability illegible, due to disappearance of the paint. In many cases these boards are still necessary. They should be painted with easily read type and placed conspicuously so as to impress the public and obtain compliance with the stated request. The fact that a notice board cannot be read, usually results in a lack of observance of a very necessary restriction on the speed of horses crossing a bridge.

The trusses should be inspected to see if they are still in line and the chords carefully examined to discover any twists or deflection and ascertain if the camber is true and uniform or irregular. All tension members should have quality of stress in each, tested by springing them with a sharp blow of the hand and particular attention to the joints of such members should be given. The posts and lateral struts should be straight and free from twists. All lateral bracing is to be examined to see that it is straight and tight, and taking such stresses as it should. In some bridges lateral members are adjustable and where such is the case, all nuts had best be tightened to a good full bearing. After the nut is tightened it should be secured by burring the thread of the bolt in two or three places with a centre punch or chisel.

Some of the pin-connected spans are detailed with the floor beams hung from the pins by a "U" bolt. A careful examination should be made to see that all nuts are tight and sound, and threads burred to prevent slackening. Also that no cracks have developed or corrosion taken place in any part of the connection. These connections should be all carefully cleaned since they are usually located in such a manner that considerable debris from the roadway is caught and held against the steel so that water is retained and assists rusting. In pin-connected bridges, any pins which indicate movement should be noted, and nuts should be examined for tightness. Any members having closed sections which catch and retain water should have proper drain holes drilled. Look for loose rods, hangers and braces and other defects of a like character which require adjusting in order that each of the different parts may have proper bearings and carry its proportion of the load. Observe the structure during the passage of a heavy load and note any undue vibration or deflection which, if followed up, may lead to the discovery of a defective part. Carefully examine the connections between stringers and floor beams and floor beam and truss. See that rivets are tight and connection angles sound. The expansion and fixed end shoes and anchor bolts also call

for careful attention to discover any movement of piers or abutments. Rollers of expansion bearings require careful cleaning to preserve them and allow proper operation. It is advisable to sweep and clean the bridge seats as often as necessary, since a considerable amount of mud usually is washed down from the roadway and, gathering around the steel, tends to induce rapid rusting.

The practical test of observing the bridge during the passage of a heavy load may result in the discovery that the various parts appear to be loose and that the entire structure appears to be working or moving. If there are a number of adjustable members in the trusses and lower laterals, it is probable that the tightening of such, while no load is on the structure, will cure any apparent looseness, while, if the bridge is fully riveted, it is desirable that close attention be given the various joints to see that rivets are still tight. If a number of loose rivets are found, it is best to cut them out and redrive so as to produce a tight joint.

Careful attention should be given to the drainage of the floor. If the bridge has a concrete floor, the drains should extend through and beyond the concrete for a distance of one or two inches and should be so placed that the drip does not strike any part of the steelwork. Drains less than three inches in diameter should not be used and they should be cleaned out at frequent intervals. Where drains have been omitted from a floor, it is desirable that holes be drilled along the curb at the low points and that suitable drains be concreted into place. The proper drainage of the floor prevents the water running off each end of the bridge where it either damages the approach roadway or carries dirt down the ballast wall to litter up the bridge seats. The bridge seats should also be examined, preferably after a rainstorm, to see if they are sloped so as to drain the water and not allow it to gather where it might assist corrosion.

Should any member of the structure be accidentally crippled while in service, the best method of repair requires careful consideration, but as a general principle, it is advisable to entirely remove the damaged part and renew it. Sections which have been subjected to heavy punishment are not reliable and a new member completes the repair in the most satisfactory manner. A slight fire on part of the structure may reach and affect some of the members and yet not cause the collapse of the bridge. The effect of such heat treatment on the strength of the steel is so uncertain that it is very desirable to remove the members which have been heated. Wooden floors of various descriptions are in some cases bad fire hazards and may imperil the entire structure. The danger to structures from fire due to nearby material or buildings is evidently not as great outside the cities, yet it is desirable that such points be kept in mind during inspections. Wood lying around on the ground under the structure, or driftwood in the river, may be the cause of trouble, if allowed to accumulate. A few dollars paid out in clearing away and carefully burning such material is usually well spent. The river above and below the site of the bridge should be inspected to see that the channel is not changing or the banks being carried away in such a manner as to sooner or later interfere with the security of the approach roadway or the abutments. Such an occurrence demands prompt attention and the supply of an ample quantity of rip-rap or the excavating of a new river bed to afford a proper escape for the water.

During repairs to the structures or flooring where traffic has to be maintained on busy roads, adequate precautions to prevent accidents to pedestrians and vehicles should be carefully taken. Proper fencing is imperative and the customary lights provided at night.

In many cases the carrying capacity of a bridge of slender appearance is seriously questioned merely because of its looks. A light steel bridge which was well built, and is properly maintained, is practically speaking, safe to-day to carry any load that can be moved along the highway. The weak part of the entire structure is usually the floor, and if that is sound, a little care is all that is required to pass the load across the bridge. It is thus possible in many instances to so maintain a bridge as to lengthen its working life and postpone the day when the expense of renewal must be considered.

In conclusion, the painting and maintaining of steel highway bridges resolves itself into a large number of small but nevertheless important details which, with proper attention, will result in the appearance of the structures being always pleasing to the eye and the constant care which is given them, will lengthen the life of the steel and prove an economy to the owners of the structure. Our highways are to receive more careful attention in the future than they have in the past and to be in accordance with that evidence of care which the roads reflect, it is imperative that the steel bridges be efficiently looked after and their maintenance kept up to the same degree of excellence.

ROAD CONSTRUCTION AS GOVERNED BY TRAFFIC REQUIREMENTS.

By Robt. C. Muir, A.M.Can.Soc.C.E., A.M.Inst.C.E.
Assistant Engineer, Department of Highways, Ontario.

TRAFFIC affects the location, grades, width and foundation of a road. It affects the decision as to the nature of surfacing to be selected. It also affects the character and the cost of maintenance. As a matter of public necessity, the roads must be made fit to bear the traffic which passes over them, and which is steadily changing in character and increasing in volume.

The practice of construction and maintenance of roads to-day is of a much more scientific nature than previously. The effects of the modern mechanically propelled traffic, especially in and around cities, requires very careful consideration, and it is left to road engineers to devise ways and means best to deal with it. Despite the change that has taken place in the methods of transport on our roads, the percentage of self-propelled vehicles to the total volume of traffic is still comparatively small, and the difficulty has still to be faced of constructing roads which will serve effectively every kind of traffic.

Construction.—Traffic affects foundations. Many road materials have been unjustly condemned when the real difficulty lay in the foundation and not in the surface material. Surfacing is secondary to foundations. It is the foundation that carries the loads coming on the road surface, where, by peculiarities of the road crust, the strains are more or less distributed at the time they reach the subgrade, and the supporting power of the foundation must be sufficient under the most unfavorable conditions likely to occur to safely resist these strains. Therefore, to determine many of the questions on foundations, it is necessary to know the kind and amount of the strains to be borne by it.

If the traffic is to be local farm and light traffic, the dependence for foundation may be placed wholly on the earth subgrade. To this end, there must be thorough drainage of the soil underlying the road. The surface for such traffic, having regard for foothold for horses, may

be built with gravel or stone and should be so compacted and bonded that it forms a waterproof covering. If the traffic is to consist of heavily loaded wagons with narrow tires, with a large proportion of heavy and fast motor vehicles, a stronger foundation is necessary. Into this field enters the Telford foundation and the concrete foundation. The more frequent and faster traffic calls for a resilient surface, such as surface treatment of tar or asphalt, commonly called a carpet coat, the heavier type of bituminous surfacing, either penetration or mixing methods, being used on roads carrying heavy motor traffic.

Grades.—The grades on a highway are affected by the character of traffic. If it be mainly pleasure, the economic disadvantages of heavy grades are not as perceptible as in the case of heavy commercial traffic conditions. Also, with some kinds of traffic, a heavy grade, if established, will result in an irresistible demand for an expensive surfacing in order that the traffic conditions may be properly met.

The damaging effect of horse traffic in particular, is considerably increased by heavy grades, the digging and pounding action of the horses' feet in drawing loads up the hill being very destructive of the road surface. On macadamized roads it loosens the surface and digs out the stones, while in wet weather the surface, being soft, is pounded to a pulp and the stones rounded in such a way that the breaking up in dry weather is greatly facilitated.

Tires.—It is plain that different tires—rubber, rubber studded with steel, steel and steel with transverse bars, as on traction engines—have widely varying effects on the surface of the road. It has often been suggested that the width of tires should be proportionate to the maximum load upon and the diameter of the wheels. There appears to be considerable difference of opinion as to the relative amount of damage caused by steel and rubber-tired wheels. It cannot be disputed that rubber-tired motor trucks are most destructive to macadam roads. It is suggested that the cause of this is to be found chiefly in the high speeds and small diameter wheels employed, together with the great weights transported and the limited use of springs. It is agreed that cross-bars should not be allowed on steel tires, but that, if the grip with smooth tires is insufficient, the surface of the tires should be grooved.

Width of Road.—The width of the roadway to be provided is determined by the traffic conditions. The determination of width for all classes of roads is of the utmost importance, and should be given careful consideration. Narrow roadways encourage the concentration of traffic and the development of ruts, especially where the shoulders are properly provided with sufficient slope (usually 1½ inches to the foot).

A committee in connection with the American Road Builders' Association recently made a recommendation that roads carrying a large proportion of fast motor traffic should have the unit width of traffic lines nine feet or ten feet, instead of seven feet or eight feet, as at present, because of the greater clearance required for safe passing of the units of such traffic.

On many of our roads vehicles are constantly forced to turn out on to the shoulders, thus causing them to wear down rapidly, and making necessary a large yearly expenditure for maintaining the shoulders.

In Britain, all main highways have been increased to a minimum width of 21 feet; also in many of the States the width of roads has been increased to 18 feet in tangent and 21 feet in curves, with 3-foot shoulders.

That the radii of curves are affected by traffic is evident when the conditions of the various classes of traffic are taken into consideration. Slow-moving horse-drawn vehicles can readily pass around much sharper curves than can fast motor vehicles. Also, in the case of the former, not as much warning of the approach of other vehicles is needed as in the latter case. Hence the necessity for unobstructed vision for a reasonable distance at curves is not as great.

In 1913 the International Association of Roads Congresses made a recommendation that the radii of curves in roads used by fast traffic should, wherever practicable, provide the best possible and an unobstructed view, and that where this is not possible, the curve being of too short a radius, means should be provided whereby the approach thereto is in some way clearly indicated.

Maintenance.—In many cases a certain minimum of traffic is required in order that the maintenance may be most satisfactory and economical. This may seem a strange statement, but nevertheless it is true, that traffic up to a certain amount is desirable on some surfaces to keep them in good condition. For instance, unless a waterbound trap rock macadam gets a sufficient amount of hard-tired traffic to produce by abrasion sufficient fine material to offset that lost through the effects of wind and rain, the condition of the road surface will not be satisfactory, and its maintenance will be expensive. The Massachusetts Highway Commission has paid about $50 per mile annually for the spreading of sand on the lightly travelled trap rock waterbound macadam roads in order to prevent the macadam ravelling after the blowing away of the fine material from its surface. Again, the sweeping effect of soft-tired motor traffic requires the abrasive effect of hard-tired traffic to counteract it. The dislodging effect of horses' feet needs the rolling effect of wheels to prevent the ravelling otherwise inevitable.

Destructive Factors.—There are three factors of traffic which may destroy the road, when it is assumed that the surface is ideal, and that the drainage and foundation are good in every respect: (1) The shocks of the horses' feet or of hard tires of vehicles; (2) the crushing effect of loads, a maximum per unit of width of tire; (3) the shearing action of motor car traffic.

High speed and small wheels, combined with heavy loading, is a destructive factor. Even exceptionally heavy loads on wheels of large diameter and reasonable width, travelling at a slow rate, cause very little damage to macadam roads in fair condition, except immediately after a frost, whereas fast traffic on small wheels and with much lighter loads soon causes considerable damage. It must, moreover, be borne in mind that the better and more regular the surface of the roads the smaller the damage, even with this type of traffic, and the damage increases at an alarming rate as the surface becomes worn and uneven.

Weather.—Where the atmosphere is generally humid, and there is a considerable proportion of wet days, the damaging effect will be greater on roads generally, and particularly on waterbound roads, than in the case of a drier atmosphere and with fewer wet days. It is not so much a question of comparing rainfall as the number of wet days and the general humidity.

Selection of Surface Material.—The road engineer must not only choose the type of surface over which it will be easiest to haul a load, which will prove durable under the traffic that it will carry, and which will be suitable to local conditions, but he must choose the surface that will produce these results with the minimum cost. It is not always possible to decide with facility what surface will prove the most satisfactory for the lowest total expenditure per ton carried over it. Nevertheless, this is the question to be solved in every new construction.

The chief points which should determine the selection of a type of surface are: (1) The volume and nature of the probable traffic over the road; (2) Conditions incident to the location of the road, including the character of the adjacent land and improvements, the character of the foundation, the existing grades, the climatic conditions, and the cost and availability of materials.

The volume and nature of probable future traffic is the most essential point. This must necessarily be approximated, and due allowance should be made for increase during the life of the road. The nature of the future traffic is difficult to foresee, owing to rapid changes in the weight and speed of motor-driven vehicles.

It has often been asked, "What type of road is best for country roads, especially those that are subjected to a mixed motor and horse-drawn traffic?" The answer to the question embraces several factors. These may be summarized under three general heads—utility, durability and cost.

One answer to this question is, to construct a surface adapted to each class of traffic; in other words, making a double roadway. This is done to the great advantage of the users of the road where the travel is sufficiently dense to require it, as adjacent to many of our cities.

Many miles of roads in New Jersey have been constructed as a double roadway in the following manner: The centre of the road is paved with bituminous concrete 2 inches thick for a width of 12 feet on a macadam foundation, and on each side of this a waterbound macadam road is constructed 6 inches thick and 4 feet wide, making a total width of 20 feet. The horses can travel on macadam surface when the bituminous surface is slippery, allowing one wheel of the wagon to run on bituminous surface, and leaving sufficient room for motor cars to run on centre of road. By following this method three ends are attained: First, the horses are able to travel over the road without slipping; second, a more satisfactory and wider road is obtained for less money; and third, there is less obstruction to traffic.

A bituminous concrete road 16 feet wide would cost more than a double road 20 feet wide. Another advantage of the latter is that the traffic would be distributed over the entire road. A road laid according to the above method would be free from the unsightly drop at edges often seen on sides of bituminous roads. This sharp drop at edges of road is very injurious, owing to the breaking off of the edges by the wheels when vehicles are driven off and on. This is most destructive to the life of the road; water is allowed into the body of the road, and as a consequence disintegration begins. The durability of the road is thus greatly lessened, as the breaking of the bond permits a movement of the stone particles. This increases the wear, thereby augmenting the cost of maintenance, with the result that the annual expenditure is increased.

It is, therefore, seen that this double roadway is the cheapest, whether measured on the basis of first or maintenance cost.

Traffic Census.—Traffic enumeration is now becoming an important element in the design of road crusts, or, at any rate, in the studies which have an influence in the choice of methods and materials. A traffic census should be considered one of the most important points in the decision of that important problem, the selection of that type of construction best suited to local conditions considered from the standpoints of both economy and efficiency.

At one time it was considered sufficient in taking a traffic census to count the vehicles passing a point in a given time, but it has now been recognized that such a method of enumeration is useless for comparing a mixed mass of traffic on one road with a mixed and possibly very dissimilar traffic on another road.

The standard system in Britain is to reduce traffic to tons per yard width of road per day. While this is a great advance on the previous method, it does not take sufficient note of the character of the traffic, each class of vehicle being given an assumed weight.

It is readily seen that tonnage alone is not the proper unit to which a reduction of the traffic census should be made. A load of four tons drawn by horses and proceeding on hard-tired wheels at three miles an hour produces quite a different effect on the road than the same load proceeding at twelve miles an hour on rubber-tired wheels on a self-propelled vehicle. A heavy touring car travelling 25 miles an hour requires quite a different consideration from those in the case of a light motor express wagon, averaging 12 miles an hour.

Conclusion.—Relation between the traffic and maintenance costs is difficult to express in any particular case. (1) Many factors other than traffic are involved, such as climatic conditions, grades and drainage; (2) the present condition of traffic records and of the records of relation of traffic conditions to wear has not reached the point where such conclusions can be drawn.

In view of the present impracticability of making roads sufficiently strong to withstand any kind of traffic, it is important that a concise record be kept of the expenditure, character, and effects of traffic, weather conditions and other details including the condition of the surface and sub-crust in respect of all roads. By this means it may be proved conclusively that the difference in cost of maintenance of the roads before and after the traffic in question comes upon them is a material amount, and that the extent of repairs is reasonable. The method of collecting evidence and of keeping accounts is a matter of extreme importance, and it would be well if some standard form were adopted.

In order to proceed with system in the matter of choice of a road, the engineer should have the necessary data as to traffic; as to cost of construction and maintenance of similar type of road under like conditions; as to the life of road; as to climatic conditions, and, in fact, all available information on the subject.

The Eugene Dietzgen Co., Limited, dealers in engineering and scientific instruments and supplies, have moved their head Canadian office from 116 Adelaide Street West, Toronto, to 31 Richmond Street West, Toronto. They now occupy the old Methodist Book Room quarters, which provide more floor space.

It is announced that the American Coal Products Company, well known in connection with the sale of sulphate of ammonia, and parent organization of the even more widely known Barrett Manufacturing Company, has decided to unite both concerns under the name of "The Barrett Company." The fact that all the roofing, waterproofing and building materials, as well as coal tar, oils, chemicals, and similar products are made and widely advertised in the name of the Barrett Manufacturing Company, has added immensely to the good-will attached to the name, which increase has not been connected in the mind of the general public with the securities of the American Coal Products Company, although this concern owns the stock of the Barrett Manufacturing Company. The commercial dealings of the American Coal Products Company included the disposal of ammonia, more especially sulphate of ammonia, which enters largely into the composition of commercial fertilizers. These transactions will be carried on by the same personnel in the name of "The Barrett Company, Ammonia Sales Agency Department." The Agricultural Department, which has carried on propaganda for the use of sulphate of ammonia as a fertilizer, will continue as a department of The Barrett Company. The Barrett products are made and sold in Canada by The Paterson Manufacturing Company, Limited, and by The Carritte-Paterson Manufacturing Company, Limited.

Editorial

CONFERENCE ON HIGHWAY CONSTRUCTION.

Beginning with this issue of *The Canadian Engineer*, and continuing through several numbers to follow, we present a series of abstracts from the papers and lectures given before the Conference on Road Construction, held at the Parliament Buildings, Toronto, during the week of February 7th. This conference, arranged especially for county road superintendents and engineers by W. A. McLean, C.E., Deputy Minister of Highways for the Province, is the second of its kind in Ontario. The first conference, held in February, 1915, was an exceedingly successful one, and its measure of usefulness, combined with the high efficiency and service of the Department, has undoubtedly established in the opinion of the Government of Ontario, as well as in the minds of the road engineers and superintendents of the province, the value of a yearly conference.

The series of lectures and demonstrations has as its chief object a means of giving departmental instruction to county engineers and superintendents who are in charge of roads subsidized by the Provincial Government under the Highway Improvement Act. The information which these lectures convey, however, is sufficiently general to be of interest to every road man in Canada. It has been presented by engineers in close touch with advanced practice, and whose knowledge of new and tried methods of construction and maintenance, as well as of materials and equipment, bespeaks a large sphere of observation and study.

Last year *The Canadian Engineer* reviewed the papers presented at the various sessions, publishing in as complete form as space would permit those of more marked interest to the majority of our readers. Through the kindness of Mr. McLean, and of Mr. Hogarth, Chief Engineer of Highways, this year's conference will be reviewed in a similar manner in so far as available space will permit.

MILITARY TRAINING AND ENGINEERING.

The Institution of Civil Engineers (London) is making special provision for candidates for admission, who, in the midst of their studies and practical work, have joined the army or navy. The council, recognizing that the unavoidable interruption, serious in any case, would make it practically impossible for many of them after the war to complete those studies and courses of training in exact accordance with the existing requirements, have submitted to the members of the Institution the desirability of modifying the requirements in order to meet such cases. With this purpose they have asked to be empowered to accept military or other approved national service as part fulfilment of the conditions of training; and, further, in certain circumstances, to exempt from examination candidates who have been engaged in military or other approved national war service for a period of at least one year.

Under the existing regulations a candidate for admission to corporate membership in the Institution is required, in addition to passing an examination, to produce evidence that he has served for at least three years as a pupil or apprentice of a civil engineer. In the case of a candidate holding a recognized qualifying degree exempting him from further examination, the period of service is reduced to two years, and may be fulfilled by service under agreement to a civil engineer.

Commenting upon the proposed modification of the standard for admission, the "Times" (London) editorially emphasizes its relation to the interests of the Institution and the public at large, membership in the former being so widely accepted as a guarantee of professional efficiency. It observes that the standard of actual efficiency required from those candidates who may be admitted under the proposed modified regulations will in effect be raised rather than lowered.

The exigencies of the war have certainly interfered with the trend of engineering study and practice. While the effect may not be so pronounced in Canada as in Great Britain, it is interesting, at all events, to learn that the governing body of the Institution of Civil Engineers contemplates professional recognition for the training that its candidates are undergoing while in service on land and sea.

SERIOUS POLLUTION OF STREAMS IN CANADA.

In "Conservation" it is stated that sewerage and sewage disposal is dealt with thoroughly in a report on "Waterworks and Sewerage Systems in Canada," to be published shortly by the Commission of Conservation. The gravity of the problem of stream pollution in Canada is shown by the great number of our inland waters receiving raw or untreated sewage. Particularly is this the case in the eastern portion of the Dominion. In the West we have the excellent example of the Province of Saskatchewan where 80 per cent. of the sewerage systems have treatment plants.

The supply of water to communities is universally recognized as the most important function of inland waters. If these waters are allowed to become polluted, they constitute a grave menace to public health. This may be the case even where filters are employed, as a grossly polluted source of supply may overload the filter, which latter should only be regarded as an additional safeguard in an operation which should begin with the proper treatment of the sewage before it is discharged into any body of water.

RAILWAY WORK IN NORTHERN ALBERTA.

The J. D. McArthur Co., which has under construction the Edmonton, Dunvegan and British Columbia Railway, the Alberta and Great Waterways Railway, and the Central Canada Railway from McLennan to Peace River, recently made some interesting announcements concerning the work projected for this year. They are as follows: The last spike on the Grande Prairie branch (60 miles) of the E.D. & B.C. will be driven in March. The Heart River bridge will also be completed next month, allowing trains to enter Peace River Crossing. Plans are being prepared for a large steel bridge across the Peace River

at this point, the cost of which is estimated at $750,000, including highway deck. This bridge will enable the Central Canada Railway to project, as contemplated, 100 miles westward. The line has been located as far as the Waterhole District.

About 340 miles of railway north of Edmonton is to be ballasted this year.

By spring it is expected that the total mileage constructed will be as follows:

E.D. & B.C. main line to Spirit River	357
Grande Prairie branch	60
Central Canada from McLennan to Peace River	50
A. & G.W.	250
Total mileage	717

These roads all were built under the guarantee policy of the provincial government and run through districts that were badly in need of railway facilities.

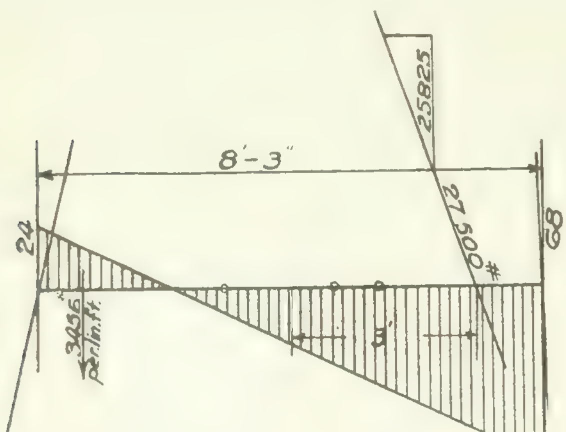
LETTER TO THE EDITOR.

An Interesting Point in Retaining Wall Design.

Sir,—An interesting point in design came up the other day and, thinking that some of your readers might be interested, I give you the problem.

The discussion came up in connection with the design for a semi-gravity retaining wall. One section of the body of the wall with the resultant stress is shown. Three methods of figuring the stresses are given. Which one is correct?

CASE I.—Figuring the stresses in the ordinary manner, we get 68 lbs. per sq. in. compression at the toe and 24 lbs. per sq. in. tension at the heel. A 9/16 inch diameter rod at 1-ft. centres placed 8 in. from back of wall would develop the entire tension.



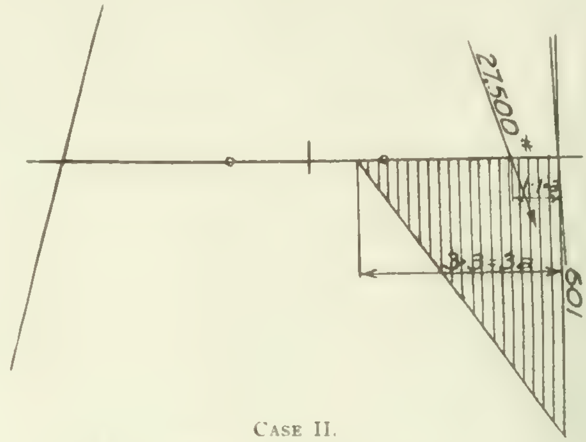
CASE I.

$$P = \frac{25825}{8.25}\left(1 \pm \frac{6 \times 3}{8.5}\right) \times \frac{1}{144} = \frac{68}{24} \text{ pds. per sq. in.}$$

CASE II.—Assuming no tension acting, we get 109 lbs. per sq. in. compression at the toe, using the formula $p = \frac{2}{3}\,\frac{V}{a}$, where V = vertical component of load and a = distance from toe to point of intersection of line of resultant with base.

CASE III.—Figuring the section as a reinforced concrete beam by commonly accepted formulæ, we require a ⅞ inch diameter rod at 12½-in. centres and get a compression at the toe of 163.5 pounds per square inch.

Should the steel be left out, as in Case II., or put in, as in Cases I. or III., in no case do we get compressive stresses that come anywhere near the working value of concrete. Both Case I. and Case III. are figured by commonly adopted theories.

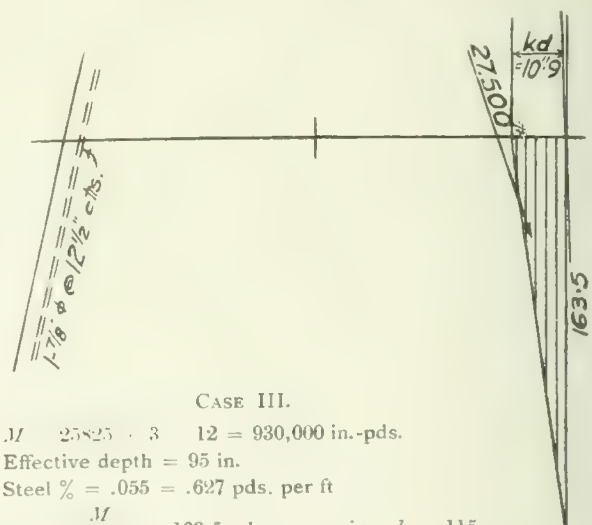


CASE II.

$$P = \frac{2}{3} \times \frac{25825}{1.1} \times \frac{1}{144} = 109 \text{ pds. per sq. in.}$$

In Case III. twice as much steel is required as in Case I., and the stress in the concrete is over twice as much.

A common method very much used is to widen the base so that the resultant will pass through the middle third, but is there any need for this when the concrete is so lightly stressed? The writer believes that as long as the resultant does not go too near the face of the wall that the stress found by Case II. is the governing factor. The opinion of other engineers would be of interest.



CASE III.

$M = 25825 \times 3 \times 12 = 930{,}000$ in.-pds.

Effective depth = 95 in.

Steel % = .055 = .627 pds. per ft

$f_c = \frac{M}{\frac{1}{2} k j b d^2} = 163.5$ pds. per sq. in. $k = .115$.

$f_s = 16{,}000$ pds. per sq. in.

E. M. PROCTOR.

Toronto, January 31st, 1916.

The Winnipeg office of The Canadian Engineer has been moved from Room 1008 to Room 1208, McArthur Building. The new telephone number is Main 2663. Mr. G. W. Goodall remains in charge of the office.

COAST TO COAST

Edmonton, Alta.—The C.N.R. is getting out 725,000 ties and 2,000,000 feet of piling for use on 100 miles of the Oliver Branch and 40 miles of the Peace River line beyond Sangudo. F. Owens, of Edmonton, has the contract.

Toronto, Ont.—Mr. H. H. Couzens, general manager of the Toronto Hydro-Electric System, reported that an expenditure of $1,375,000 was necessary to provide adequate extensions and equipment for the System. An issue of debentures for this amount is under consideration.

Toronto, Ont.—Good progress is being made by the Hamilton Bridge Co., sub-contractors for steel under Quinlan and Robertson on the Don Section of the Bloor Street Viaduct. The same applies to the Rosedale Section, which the Dominion Bridge Co. has under contract. On both sections the contractors are considerably ahead of schedule.

Galt, Ont.—The electrification of the Galt-Elmira branch of the G.T.R. was discussed at a city council meeting recently. It was pointed out that the line should be continued to Hamilton and Niagara Falls, and it was also proposed to construct a branch radial to Guelph. The electrification of the Galt-Elmira branch was strongly favored.

Kingston, Ont.—The Board of Trade is agitating for a better harbor, and has approached the government in the matter. It is desired to improve the present harbor to enable it to receive vessels of increased tonnage for the traffic that results from the completion of the new Welland Ship Canal. It is proposed to dredge the harbor to 25 feet in depth.

Ottawa, Ont.—According to Hon. Frank Cochrane, Minister of Railways and Canals, up to January 1st, 1916, $5,018,711 had been spent in dredging, lighting and other improvements at Port Nelson. It would take another $5,000,000 to complete these harbor improvements. On the Hudson Bay Railway, $9,957,340 had been spent to date and $5,500,000 would be required to finish the work.

Ottawa, Ont.—The new pumping plant at Lemieux Island, together with alterations and improvements to intake pipes, have enabled the maximum pumping capacity of the city to be raised from 22,500,000 gallons to 27,000,000 gallons per day, the latter figure having been reached at one period during the recent Parliament Buildings fire. The average pumping rate at present is about 19,000,000 gallons per day.

Toronto, Ont.—Special legislation may be necessary for an arrangement between the city and the township of York whereby the latter may obtain a water supply from the former. The matter is under consideration at the present time. Although the city is now using about 50,000,000 gallons per day, and is pumping only enough for its own requirements, it is stated that by June next the pumping capacity will have been increased to 110,000,000 gallons per day.

Lethbridge, Alta.—The Dominion Government contemplates an irrigation project north of this city that will comprise about 100,000 acres. The engineering staff of the Department has been working on detailed surveys for some time. There are several other projects under way, such as the Taber extension (nearing completion) comprising 17,000 acres, and also a 350,000-acre block east of Lethbridge, upon which the Irrigation Branch of the Department are at present conducting surveys.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The February meeting of the Toronto Branch of the Canadian Society of Civil Engineers was held at the Engineers' Club, Toronto, on the 10th inst., Mr. G. A. McCarthy, chairman of the Branch, presiding.

During the business session preceding the presentation of the technical subject under discussion for the evening, the secretary, Mr. L. M. Arkley, read a letter from Prof. C. H. McLeod, secretary of the Society, announcing that at the recent annual meeting a resolution had been adopted providing for the election of a committee to devise ways and means of increasing the prestige and activities of the Society, and calling upon the Toronto Branch to make six or more nominations from which three would be elected as representatives of the Toronto district. The members nominated at the meeting were Messrs. G. A. McCarthy, J. R. W. Ambrose, J. G. G. Kerry, A. F. Macallum, S. B. Clement, H. E. T. Haultain, E. W. Oliver and A. H. Harkness. The executive was given power to make an alternative nomination in the case of any of the above desiring not to act.

When this and other business was concluded, Mr. G. R. G. Conway, consulting engineer, Toronto, gave an informal lecture on "Recent Dam Construction in British Columbia," with particular reference to work with which he has been associated as chief engineer and consulting engineer.

The lecture, which was illustrated with a fine series of lantern views, described the construction of the Bear Creek dam on Vancouver Island, which forms one of a number of dams built for the storage of water at Jordan River, 40 miles west of the city of Victoria, for the hydro-electric plants of the British Columbia Electric Railway Company.

This dam is 1,020 feet in length and 50 feet in height, with 2½ to 1 downstream slope and 3 to 1 upstream slope, and contains 148,400 cubic yards of material. The dam was built by the hydraulic process and impounds 328 million cubic feet of water, the top elevation being 1,483 feet above sea level.

Five miles below Bear Creek dam has been constructed the Jordan River dam of the "Ambursen" type, which is the highest dam in Canada, the extreme height being 128 feet. It is, so far, the second highest reinforced concrete dam that has been built, the highest being the La Prele dam in Wyoming, which has a maximum height of 136 feet. The Jordan River dam is 891 feet in length with a spillway 305 feet long provided with 8 feet of free-board. It contains 21,200 cubic yards of concrete and 380 tons of reinforcing steel was used in its construction. The dam impounds 612 million cubic feet of water, the top elevation being 1,360 feet. From this dam the main water supply is delivered by flume to a forebay from which the penstock pipes are taken so as to utilize a head of 1,145 feet at the power house where impulse wheels have been installed to a capacity of 25,000 horse-power.

Mr. Conway also described the construction features of Coquitlam dam which impounds water for the Coquitlam-Buntzen hydro-electric project of the British Columbia Electric Railway Company. This dam, which is the best and largest example of hydraulic fill construction in Canada, is 99 feet in height, 950 feet in length exclusive of spillway. The storage obtained by building this dam amounts to 180,500 acre-feet, or 7,873 million cubic feet.

The lecturer described in detail the hydraulic sluicing operations in which 4-inch and 5-inch monitors were employed with a nozzle pressure of 80 lbs. per square inch.

Of the 550,000 cubic yards of material in the dam, 427,000 cubic yards was placed in position by sluicing, the remainder—consisting of heavy rock toes—being placed by electrically operated cableways.

A description was also given of the intake works for the supply of water to New Westminster, and some interesting data regarding the rainfall in this part of British Columbia, which has varied at Coquitlam between the extremes of 132 inches and 190 inches, the average being 153 inches per annum.

At the conclusion of the paper an interesting discussion took place and many questions were asked the lecturer.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Calgary Branch of the Canadian Society of Civil Engineers held its second dinner of the season at the Alexandra Hotel at 6.30 p.m., February 3, 1916. About 70 members and guests were present. After the dinner Mr. C. D. Howe, chief engineer, Dominion Government Grain Commission, addressed the society on the subject of "Government Elevator Construction." His address was fully illustrated with lantern slides. It was listened to with much interest by the members present and a general discussion followed.

The Calgary Branch expects to be favored with an address by Mr. J. G. Sullivan, chief engineer, Canadian Pacific Railway Company, on the Roger's Pass Tunnel, at an early date.

PERSONALS.

THOS. RODGER has been appointed superintendent of telegraphs for the Grand Trunk Railway System.

JAMES MACKINTOSH, of Hydroglen, Ont., has been elected an associated member of the Institution of Civil Engineers (London).

C. W. PRICE, formerly assistant superintendent of the Sydney Division of the Intercolonial Railway, has been appointed terminal manager at Moncton, N.B.

F. M. BRICKENDEN, until recently a member of the city engineer's staff of London, Ont., is now a lieutenant in the Engineers' Training Depot, Ottawa.

A. J. LATORNELL, B.A.Sc., A.M. Can. Soc. C.E., has resigned his position as city engineer of Edmonton, Alta., in order to enlist for overseas service. Mr. Latornell has been city engineer of Edmonton since 1908, for two years prior to which he was assistant city engineer.

C. W. BAKER, B.Sc., of the Canadian Westinghouse Company, addressed a meeting of the Hamilton Scientific Association last week on the subject of "The Development and Utilization of Electricity."

K. F. NYSTROM, chief draughtsman of the car department of the Grand Trunk Railway, addressed the February meeting of the Canadian Railway Club on "Improvement in Passenger Car Construction and Design."

Lieut. R. H. HOPKINS, formerly a lecturer in electrical engineering, University of Toronto, and a lieutenant in the C.O.T.C., but at present attached to the 39th Battalion, now in England, was severely injured in a motor car accident, in which his brother, Lieut.-Col. F. H. Hopkins, lost his life.

JOHN HADDIN, M.Can.Soc.C.E., A.M.I.C.E., and E. L. MILES, A.M.Can.Soc.C.E., who have for many years been in partnership as consulting engineers under the name of the John Galt Engineering Co., Limited, have changed the firm name to Haddin & Miles, Limited. They are retaining their offices and organization in Winnipeg and Calgary as previously.

Sergeant GEO. LAW, formerly superintendent for Foley Bros., Welch and Stewart on railway construction, and later with the Cook Construction Company on the double-tracking of the C.P.R. west of Sudbury, Ont., has received the Distinguished Conduct Medal. Sergeant Law is with the 2nd Field Company, Canadian Engineers, and went to the front with the First Contingent.

Lieut. JAMES CAMPBELL McDONALD, B.A., A.M.Can.Soc.C.E., graduate of Dalhousie University, Halifax, N.S., and now in the Engineering Corps of the 1st Canadian Contingent, has, according to a recent list of honors to officers and men of the Canadian Expeditionary Force, been awarded the Military Cross. Lieut. McDonald served in the South African war under Major Stairs, of Halifax, and in recent years was with the firm of Cleveland & Cameron, Vancouver.

OBITUARY.

The death occurred in Winnipeg on February 2nd of Mr. Duncan MacDonald, a well-known railway contractor of Western Canada. The deceased was in his 75th year.

The death occurred in London, Eng., on February 9th of Sir Charles Rivers-Wilson, formerly president of the Grand Trunk Railway, which position he held from 1895 to 1909. For 20 years previous to this distinctive connection with railway development in Canada the deceased was associated with the construction and operation of the Suez Canal.

THE USE OF INFILTRATION GALLERIES IN WATER SUPPLY.

(Continued from page 262.)

successful results on Long Island show the maximum possibility of such a supply.

In tropical countries, where there exists so strong a prejudice against the use of stored surface water for a public water supply, due to the deterioration resulting from the luxuriant vegetable growth abounding in such waters, the use of an infiltration gallery is often advisable. The natural purification which takes place in the water while passing from the surface reservoir to the infiltration gallery has been found to be effective. The ability to economically produce a good, clean potable supply even from a very inferior raw water by double filtration, or by other methods, has not been generally recognized. It appears that ground waters are largely preferred, and the proper use of infiltration galleries alone or as a supplement to a well supply is an important matter.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

A special meeting of the above society will be held on Friday, February 18th, to consider the nominations for the reorganization committee of the society.

Volume 30. Toronto, February 24, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

STRESSES IN LATTICE BARS OF CHANNEL COLUMNS

DERIVATION OF THEORETICAL FORMULA THAT TAKES LENGTH INTO CONSIDERATION AND THEREFORE ALLOWS FOR STRESS CAUSED BY BENDING AND THAT ALSO AGREES CLOSELY WITH ACTUAL TEST RESULTS.

By William Worth Pearse, C.E.,

City Architect and Superintendent of Building, City of Toronto.

FORMULÆ for calculating stresses in lattice bars of columns have hitherto generally been considered empirical, but the writer believes that in the following will be found a theoretical formula which will meet any and all conditions, and which checks up with actual tests.

As a matter of history, it might be noted that on November 2nd, 1907, an article by the writer was published in Engineering Record, of New York, in which the writer evolved a formula for transverse shear which has since been adopted by several authorities, but which does not take into account the length of the column. In the following article the writer has evolved a formula which takes length of column and bending into account.

The formula published nine years ago was as follows:

$$R = \frac{232\,Ar}{n} \quad \text{[Equation a.]}$$

where A = area of column.

r = radius of gyration, axis parallel to back of channels.

n = distance from neutral axis to extreme fibre.

Equation a was derived from the New York law for columns, as follows:—

$$\frac{P}{A} = 15{,}200 - 58\frac{l}{r} \quad \text{[Equation b.]}$$

Now, if the American Railway Engineering Association's formula is used, which is

$$\frac{P}{A} = 16{,}000 - 70\frac{l}{r} \quad \text{[Equation c.]}$$

then

$$R = \frac{280\,Ar}{n} \quad \text{[Equation d.]}$$

Equation d is the value for the transverse shear adopted by several authorities. It can easily be proven by direct proportion that Equation a and Equation d are similar, as follows:—

$$58 : 70 :: 232 : x$$

Therefore, $x = 280$.

It will be noticed that in Equations a and d the length does not appear.

Now, it is evident if we put $l = 0$ in Equations b and c that the quantity to be deducted due to bending drops out, and that nothing would be deducted due to the bending of the column, or in other words as the length of the column approaches zero, the stress to be deducted due to the bending also approaches zero, or there is a much greater stress in the column due to bending when the column is long. As it is only the stress caused by the bending of the column that causes any stress in the lattice bars, it is evident that the longer the column is, the greater must be the stress in the lattice bars.

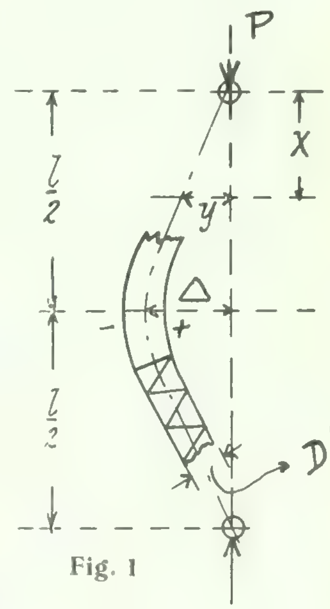


Fig. 1

By referring to Table No. 1, it will be noticed that the stresses for different lengths vary. Columns 9′ 0″ long have much less stress in the lattice bars than columns 20′ 0″, of the same cross-sections. (See Column 2 of Table No. 1.) It is, therefore, evident from the above that Equations a and c are incorrect except for one length of column, whatever that length may be.

For the same reason, the ratio given in Bulletin No. 44 of the University of Illinois, which was given as .0251 of the compression load, can only be correct for columns having a ratio of $\frac{l}{r} = 37.8$, or thereabouts. By referring again to Table 1, Cols. 11 and 12, it will be seen that for approximate ratios of $\frac{l}{r} = 37.8$, that the ratio .0251 compares very closely indeed with the result of the formula given hereafter.

Derivation of Formula.—Referring to Fig. 1, it has been assumed that column is hinged top and bottom, and that a load P is applied top and bottom.

If the column is very short the material will be crushed and there will be an even pressure over both channels, as shown by Fig. 2, and equal to S_0 per square inch.

Fig. 2.

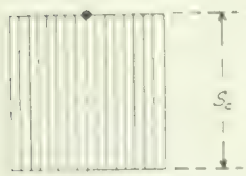
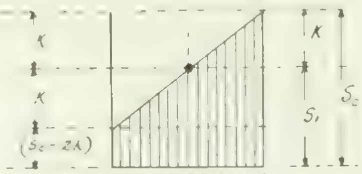


Fig. 3.



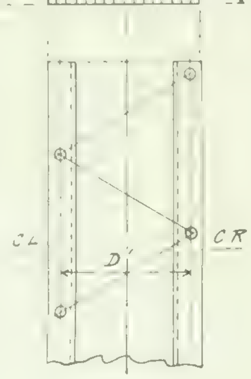


Fig. 4.

If the column is long, it will fail by bending and there will be tension on one side and compression on the other, or, by referring to Fig. 3, it will be seen that there is a difference of stress between the two channels equal to $2k$.

Or the total stress in channel marked C.R. would be $2k\frac{A}{2}$, due to bending.

Let S_0 = 16,000 lbs. = allowable pressure per square inch when column is very short, and S_1 = allowable average pressure per square inch for long columns.

Then, $(S_0 - S_1)$ = stress per square inch due to bending of column at centre = k, and $(S_0 - S_1)A$ = total stress in column at centre due to bending of column. [Equation 1.]

A = area of column.

Referring to Merriman's Mechanics of Materials, 1894 edition, page 132, he gives what he considers the most accurate column formula for

$$\frac{P}{A} = S_1, \text{ namely,}$$

$$\frac{P}{A} = \frac{S_c}{1 + \frac{S_0}{m\pi^2 E}\frac{l^2}{r^2}} \quad \text{[Equation 2.]}$$

Substituting usual values in Equation 2,

$$S_1 = \frac{16{,}000}{1 + \frac{1}{12{,}000}\frac{l^2}{r^2}}. \quad \text{[Equation 3.]}$$

Referring to Fig. 3 and Fig. 4 it will be noticed that the right-hand channel (marked C.R.) has a stress per square inch = S_c, while channel marked C.L. has a stress per square inch = $S_0 - 2k$, making a difference in stress per square inch between the two channels of $2k$ per square inch.

But $k = (S_c - S_1)$. [Equation 4.]

Therefore, $2k = 2(S_0 - S_1)$. [Equation 5.]

Then the total stress in channel (marked C.R.) due to bending is $= 2k\frac{A}{2} = 2(S_0 - S_1)\frac{A}{2}$. [Equation 6.]

Now referring to Fig. 1:—

When a long column is loaded it will bend as stated before, and the curve it will take will be a sinusoid whose equation is $y = \Delta \sin \pi \frac{x}{l}$. [Equation 7.] (Hinged ends only. If column is not hinged top and bottom, then the general equation for the flexure of the column will become $y = \Delta \sin n\pi x/l$. If one end is fixed and the other end is round, then $n = 2$. If both ends are fixed, then $n = 3$. The above equations would have to be used in place of Equation 7.)

(See Merriman's Mechanics of Materials, 1894 edition, page 115.)

Let M = bending moment at centre of column, then $M = P\Delta$.

Total stress in one channel due to

$$M = \frac{M}{D'}, \text{ and } \frac{M}{D'} = \frac{P\Delta}{D'}. \quad \text{[Equation 8.]}$$

But it was found in Equation 6 that the total stress in one channel was equal to $2(S_0 - S_1)\frac{A}{2}$.

Therefore $\frac{P\Delta}{D'} = 2(S_0 - S_1)\frac{A}{2}$. [Equation 9.]

Or, $\Delta = D'\frac{(S_0 - S_1)A}{P}$. [Equation 10.]

m = bending moment at any point x.

$= Py$. Substitute for y, (see Equation 7),

$= P\Delta \sin \pi \frac{x}{l}$. [Equation 11.]

Substitute for Δ, (see Equation 10),

$$m = \frac{P D' (S_c - S_1) A}{P} \sin \pi \frac{x}{l}.$$

Or, $m = D' (S_0 - S_1) A \sin \pi \frac{x}{l}$. [Equation 12.]

Now, stress in channel at any point $x = \frac{m}{D'} = p$.

Therefore, $\frac{m}{D'} = \frac{D'(S_0 - S_1)A}{D'} \sin \pi \frac{x}{l}$.

Therefore, $\frac{m}{D'} = (S_c - S_1) A \sin \pi \frac{x}{l} = p$. [Equation 13.]

Referring to Fig. 5:—

The stress in end lattice bar $bc = p \sec \phi$.

Therefore, stress in end lattice bar

$bc = (S_c - S_1) A \sin \pi \frac{x}{l} \sec \phi$. [Equation 14.]

But there are two lattice bars; therefore,

$$bc = \frac{(S_c - S_1) A \sin \pi \frac{x}{l} \sec \phi}{2}. \quad \text{[Equation 15.]}$$

But angle ϕ is usually 60° and the secant of 60° is 2; therefore, stress in each lattice bar

$$bc = (S_0 - S_1) A \sin \pi \frac{x}{l}. \quad \text{[Equation 16.]}$$

If Equation 16 is solved, it will give the stress in each end lattice bar when ϕ is 60°, and as the end bar takes a maximum shear, all that it is necessary to do is to design the end bar and make the remainder of the bars the same size.

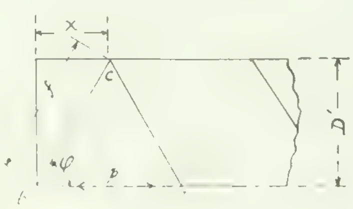


Fig. 5.

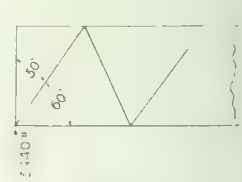


Fig. 6.

To find the stress in the lattice bars for any other angle than ϕ = 60°, use Equation 15, which is a general equation.

TABLE No. 1.—For Design of Lattice Bars of Columns.

(This is probably the first table ever published for this purpose that is worked out in such manner that a draftsman can use it for ready reference. A copy of this table, mounted on stiff cardboard and strung ready to hang, will be mailed free to any reader upon request to *The Canadian Engineer*.)

1	2	3	4	5	6	7	8	9	10	11	12	13.
L Length in feet.	Sije of Channels.	A. area of Section sq. inches	D. Distance C to C of rivets perpendicular to axis of column	r.	$\frac{L}{r}$	x.	$\sin \pi \frac{x}{L}$	S_1 Allowable stress per sq. inch on long columns lbs.	$S_c - S_1$ Stress per sq. inch due to bending of column lbs.	Stress in each end lattice bar lbs.	Stress in end lattice bar according to tests. lbs	Sije of Lattice bars.
9'-0"	2-6"@8#	4.76	5¾"	2.34	46	3.32"	.096	13600	2400	1100		2¼" × 5/16"
"	2-7"@9¾#	5.7	6¾"	2.72	40	3.9"	.113	14200	1800	1160	1170	"
"	2-8"@11¼#	6.7	7½"	3.11	34	4.33"	.126	14600	1400	1180		"
"	2-9"@13¼#	7.78	8¼"	3.45	31	4.76"	.139	14800	1200	1290		"
"	2-10"@15#	8.92	9¼"	3.81	29	5.34"	.156	14950	1050	1450		"
"	2-12"@20½#	12.06	11¼"	4.61	23	6.5"	.19	15350	650	1484		2¼" × 3/8"
"	2-15"@33#	19.8	13¼"	5.6	19	7.65"	.221	15550	450	1870		2½" × 7/16"
12'-0"	2-6"@8#	4.76	5¾"	2.34	61	3.32"	.073	12200	3800	1300		2¼" × 5/16"
"	2-7"@9¾#	5.7	6¾"	2.72	53	3.9"	.086	12950	3050	1360		"
"	2-8"@11¼#	6.7	7½"	3.11	46	4.33"	.096	13650	2350	1420		"
"	2-9"@13¼#	7.78	8¼"	3.45	42	4.76"	.104	14000	2000	1600		"
"	2-10"@15#	8.92	9¼"	3.81	38	5.34"	.116	14300	1700	1760	1848	"
"	2-12"@20½#	12.06	11¼"	4.61	31	6.5"	.142	14800	1200	2030		2½" × 3/8"
"	2-15"@33#	19.8	13¼"	5.6	25	7.65"	.165	15200	800	2600		2½" × 7/16"
15'-0"	2-6"@8#	4.76	5¾"	2.34	77	3.32"	.058	10700	5300	1450		2¼" × 5/16"
"	2-7"@9¾#	5.7	6¾"	2.72	66	3.9"	.07	11700	4300	1670		"
"	2-8"@11¼#	6.7	7½"	3.11	58	4.33"	.076	12500	3500	1770		"
"	2-9"@13¼#	7.78	8¼"	3.45	53	4.76"	.082	13000	3000	1930		"
"	2-10"@15#	8.92	9¼"	3.81	46	5.34"	.093	13650	2350	1940		"
"	2-12"@20½#	12.06	11¼"	4.61	39	6.5"	.113	14200	1800	2560	2480	2½" × 3/8"
"	2-15"@33#	19.8	13¼"	5.6	32	7.65"	.133	14700	1300	3400		2½" × ½"
18'-0"	2-6"@8#	4.76	5¾"	2.34	92	3.32"	.048	9350	6650	1510		2¼" × 5/16"
"	2-7"@9¾#	5.7	6¾"	2.72	80	3.9"	.056	10700	5300	1700		"
"	2-8"@11¼#	6.7	7½"	3.11	70	4.33"	.064	11380	4620	1940		"
"	2-9"@13¼#	7.78	8¼"	3.45	63	4.76"	.068	12000	4000	2120		"
"	2-10"@15#	8.92	9¼"	3.81	57	5.34"	.078	12600	3400	2340		"
"	2-12"@20½#	12.06	11¼"	4.61	45	6.5"	.093	13650	2350	2680		2½" × 3/8"
"	2-15"@33#	19.8	13¼"	5.6	39	7.65"	.11	14200	1800	3937	4077	2½" × ½"
20'-0"	2-10"@15#	8.92	9¼"	3.81	63	5.34"	.07	11400	4600	2860		2½" × 3/8"
"	2-12"@20½#	12.06	11¼"	4.61	53	6.5"	.084	12950	3050	3120		"
"	2-15"@33#	19.8	13¼"	5.6	42.8	7.65"	.10	13900	2100	4060	3973	2½" × ½"

AUTHOR'S NOTE—Size and weights of channels referred to in Table 1 were taken from the Cambria Steel Company's handbook, as were also the distances back to back of the channels. The lattice bars for the smaller columns might be smaller, but it was assumed that 2¼" was the narrowest distance to take, due to punching and riveting, but different sizes may be substituted by designing the bars according to Equation 18. Sizes of lattice bars given in the last column of Table 1 were figured by Equation 18.

Each end lattice bar would have to be designed to act as a column having a length equal to f and a load equal to y.

Referring to Bulletin No. 44 of the University of Illinois, page 47, they give a formula for lattice bars as columns based on actual tests:—

$$\frac{P}{A} = 21,400 - 45\frac{l}{r}. \quad \text{[Equation 17.]}$$

Equation 17 gives the ultimate fibre stress per square inch; therefore, the safe load would be

$$\frac{P}{A} = 6,600 - 45\frac{l}{r}. \quad \text{[Equation 18.]}$$

Equation 18 is using a factor of safety of 3¼, which is about the same as is given in Equation 3.

From Equation 16, Table No. 1 was figured, which gives the stress in the end lattice bars for channel columns having lengths of 9′ 0″, 12′ 0″, 15′ 0″, 18′ 0″ and 20′ 0″. For intermediate lengths it would be safe to interpolate. For different areas, it will be directly proportional to the area, as will be seen by referring to Equation 16.

Application of Formula.—Now, to prove that Equation 16 is correct and agrees with experiments, one refers to Bulletin No. 44 of the University of Illinois, page 33, supplementary to Table 6, which gives in the last column of the table "Ratio of transverse shear to compression load = .0251."

This was the results of tests on "Column 1."

Referring to page 10 of the bulletin, a full description is given of Column 1, as follows:—

$A = 18.76$, $L = 21' \, 0''$, $\frac{l}{r} = 37.8$, angle of lattice bar with axis of column = 63° 30′.

It seems reasonable that all columns having a ratio of $\frac{l}{r} = 37.8$, or thereabouts, and having the lattice bars sloping approximately 63° 30′, should have a ratio of transverse shear to compression load = .0251. Referring to Table 1, on page 254, it will be noticed that for two channels 15″ at 33 lbs., 20′ 0″ long, the stress given in the end lattice bar is 4,060 lbs. $\frac{l}{r} = 42$, which is reasonably close enough to what is given in the tests to give approximately the same results; therefore, we get, for transverse shear, the following where $A = 19.8$ and the compressive load per square inch = 13,900 lbs.; and therefore transverse shear = 19.8 × 13,900 × 0.0251 = 6,880 lbs.

There are two lattice bars, therefore $\frac{6,880}{2} = 3,440$ lbs. transverse shear on each lattice bar. (See Fig. 6.)

The secant of 30° = 1.155, therefore 3,440 × 1.155 = 3,973 lbs. stress in end lattice bar, which is very nearly what is given in Table 1, which is 4,060 lbs.

Referring to Table 1 again, it will be noticed that for two channels 7″ at 9¾ lbs., 9′ 0″ long, that $\frac{l}{r} = 40$, $S_1 = 14,200$ lbs. and stress in end lattice bar is 1,160 lbs. $A = 5.7$ square inches.

Therefore, transverse shear = 5.7 × 14,200 × 0.0251 = 2,030 lbs.

Therefore, $\frac{2,030}{2} = 1,015$ lbs. transverse shear for each lattice bar.

Then, 1,015 × 1.155 = 1,170 lbs., which is within 10 lbs. of that given by the formula, which is 1,160 lbs.

Referring to Table 1, two channels 10″ at 15 lbs., 12′ 0″ long, $\frac{l}{r} = 38$, $S_1 = 14,300$ lbs. per square inch, $A = 8.92$ square inches, stress in lattice bar = 1,760 lbs.

Transverse shear = 8.92 × 14,300 × 0.0251 = 3,200 lbs. Therefore, $\frac{3,200}{2} = 1,600$ lbs. transverse shear for each lattice bar.

Then, 1,600 × 1.155 = 1,848 lbs. stress in lattice bar, which is within 88 lbs. of what is given in Table 1.

Referring to Table 1, two channels 12″ at 20½ lbs., 15′ 0″ long, $\frac{l}{r} = 39$, $S_1 = 14,200$ lbs. stress in lattice bar = 2,560 lbs., $A = 12.06$ square inches.

Transverse shear = 12.06 × 14,200 × 0.0251 = 4,300 lbs. Therefore, $\frac{4,300}{2} = 2,150$ lbs. transverse shear for each lattice bar.

Then, 2,150 × 1.155 = 2,480 lbs. stress in lattice bar, which is 80 lbs. less than what Table 1 gives.

Referring to Table 1, two channels 15″ at 33 lbs., 18′ 0″ long, $\frac{l}{r} = 39$, $S_1 = 14,200$ lbs., stress in lattice bar = 3,937 lbs., $A = 19.8$ square inches.

Transverse shear = 19.8 × 14,200 × 0.0251 = 7,060 lbs. Therefore, $\frac{7,060}{2} = 3,530$ lbs. transverse shear for each lattice bar.

Then, 3,530 × 1.155 = 4,077 lbs., stress in lattice bar, which is 140 lbs. more than what Table 1 gives.

Note—There are certain secondary stresses caused by inaccuracy in fabrication which cannot be covered by any formula that could be derived. This, no doubt, explains the slight difference between the results of the tests and the results obtained by use of the formula. One must take into account, also, the possible errors due to readings of the extensometers.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.

As previously announced in these columns the third annual meeting of the above Congress will be held in Montreal at Sohmer Park, from March 6th to 10th, 1916.

A special effort is being made to get together influential members of all the societies interested in the Good Roads Movement, and as a result it is expected that the Congress will be made up of men from all branches of public life—Government officials, engineers and automobile owners being particularly in evidence.

The Eastern Canadian Passenger Association has agreed to grant reduced fares to all persons attending. Among the many papers to be discussed will be a paper on Road Laws, in which will be fully explained the legislation under which the provincial governments extend aid to municipalities for road improvements and the various statutes upon which municipal organization for road purposes is based. Also of equal importance will be a paper on traffic regulations. Other papers to be discussed will deal with subjects which come under the following heads: Road Foundations, Wearing Surface, Bridges and Culverts, Road Machinery, Road Maintenance and Materials of Road Building.

The officers of the Congress are: B. Michaud, president; O. Hezzlewood, vice-president; Geo. McNamee, secretary-treasurer; and A. H. Dandurand, W. A. McLean, Howard W. Pillow, J. Duchastel, L. A. Sanderson, members of committee.

The secretary's office is located in the new Birks Building, Montreal, P.Q.

LIMITATIONS OF RESULTS OF TESTS OF BITUMINOUS MATERIALS.

HAVE analyses of bituminous materials any real meaning to the municipal or highway engineer or road contractor? Are chemists' tests reliable; and when made on bituminous materials, are they anything but means of identification?

These questions are raised by a lecture on the limitations of the value of making tests on bituminous materials, which was given in the graduate course in highway engineering a couple of weeks ago at Columbia University by Chas. N. Forrest, of Maurer, N.J., who is chief chemist of the Barber Asphalt Paving Co.

Mr. Forrest says that the first application of bituminous materials for paving purposes was not likely preceded by laboratory tests of any kind, and that, at any rate, the earlier schemes for testing such substances did little, if anything, more than to identify the material under examination.

After a bituminous pavement was laid that was enough of a success to cause it to be conspicuous, Mr. Forrest says, the services of a chemist were employed to take the thing apart and determine of what it was made.

The function of all bituminous materials in a pavement is physical rather than chemical, as they are all chemically inert so far as concerns any influences to which they are subjected in normal service. An exception to this is the creosote oil used for impregnation of wood paving block, which must have certain chemical properties to perform its proper function. With the exception of creosote, however, Mr. Forrest claims that practically all of the tests now applied to bituminous materials, by those who are concerned in their application to roads, come within the classification of proximate analyses, and do not disclose the ultimate composition of the substances. He says they merely reveal certain of its characteristics, chiefly physical, when applied in very strict accordance with some prescribed method.

A great deal of time and thought has been given to the question of standardization of the methods employed in bituminous analyses. The standardization of methods for tests is of more importance, thinks Mr. Forrest, than the drawing of general specifications, as there can be no proper understanding of specifications until there is unanimity of opinion as to how the characteristics mentioned in them are to be determined. The following is an abstract of the portion of Mr. Forrest's lecture which deals with the difficulty in making, and the value or otherwise, of tests on bituminous paving materials:—

The standardization of the methods for performing tests of bituminous materials has not yet been satisfactorily accomplished, but is progressing slowly, and in the meantime a full description of the method which is to be employed should accompany all specifications, if confusion is to be avoided.

That there is considerable divergence of opinion as to the most suitable method for performing many of the tests, and a still greater divergence upon the results obtained, is appreciated by all who have been concerned in either the manufacture, sale or purchase of bituminous materials for any length of time.

Specific Gravity.—There is not much room for honest disagreement upon the subject of specific gravity, yet in view of the fact that that characteristic varies with temperature and such viscous substances as many of those involved are, are prone to entangle air and moisture, there has been more or less controversy over this simple matter. As this characteristic of bituminous materials frequently plays an important part in the computation of quantity delivered, and slight errors in the laboratory determination of specific gravity multiply into very considerable differences between what is shipped at one point and received at another, it is worthy of careful consideration.

The temperature of bituminous materials affects practically all of the physical tests to which they are subjected, and too much care cannot be exercised to insure the specific temperature specified, being the actual condition of the material under examination and not merely that of the surrounding air or water which may envelop it at the time. This class of material absorbs and radiates heat slowly and the period of time stated in a method, through which a sample is to remain in water, or the procedure to be followed in heating or cooling it, must necessarily be based upon considerable experience in such matters and must also be religiously followed if accuracy is important.

While there may not be much room for honest disagreement upon the subject of specific gravity, there is no limit to either the room for or the degree of disagreement in regard to practically all of the other tests to which bituminous materials are submitted.

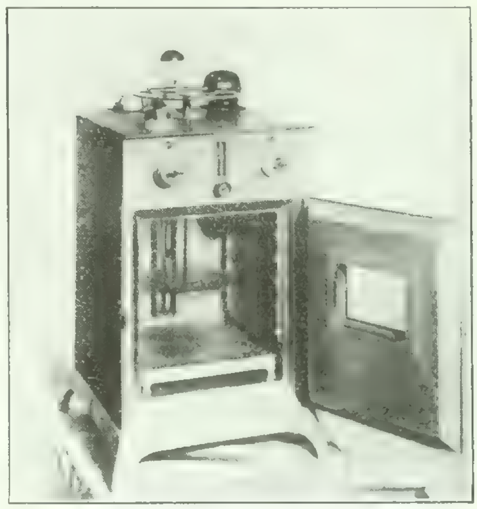


Fig. 1.—Improved Freas Oven for Loss on Heating Test of Bitumens.

Flash Point.—In addition to the dozens of miscellaneous independent methods used for the determination of the flash or fire point, or both, there are as many as at least eight more or less standard methods for the same purpose which may be described under the name of the apparatus used for the purpose. The eight standard methods are as follows: Tagliabue, open and closed cup; New York State, closed cup; Cleveland, open cup; Abel, closed cup; Abel-Pensky, closed cup; Pensky-Martin, closed cup; Bureau of Mines, closed cup.

No open-cup method will yield results capable of duplication in the hands of different operators, and the value of any results so obtained is questionable. The results obtained under unlike conditions, either as to type or cup, or its manipulation, are not comparable. The closed cup tests can be checked to a single degree.

Penetration.—At the present time there are several different instruments (Bowen Penetration Machine, Dow Machine, N.Y.T.L. Penetrometer, Abraham's Consistometer) and methods for the determination of the consistency or penetration of bituminous materials, although but one of each is in general use. As is well known, the principle of this test is to determine the depth to which a standard needle under a definite load will penetrate at a

stated temperature and in a stated period of time. There are several variables or opportunities therefor in this test and these must be taken care of at the outset. The consistency of bituminous materials is an adjustable characteristic and, without consideration of any other feature, may be regulated in terms of the apparatus referred to, to any degree desired, but as to what is a proper penetration for a given material or a stated purpose, depends entirely upon experience with both that material and purpose and where the purpose is located.

The penetration of different classes of bituminous materials is not always a correct indication of their relative consistency due to the fact that very adhesive substances retard the progress of the needle, by clinging to its sides, while more oily and harder substances may encourage its progress. The diameter and depth of the vessel in which the substance under examination is tested, and whether its surface is covered with water or exposed to the air, may also influence the result.

Disagreement in the results of this test by different operators is more frequently due to temperature variations in the sample than any other cause, although a dull needle, too small sample, or lack of the "knack" of manipulating the test are sometimes contributory causes. Some experience is necessary to perform the test satisfactorily. After all conditions are correct, it is conceded that a difference of four points is satisfactory agreement between different operators.

Melting Point.—The number of different methods which have been proposed for the determination of the so-called melting point of bituminous materials probably exceeds that of flash point methods. Those with which the author is familiar are as follows: Cube on mercury; Mabery; Kramer & Sarnow and modifications; ball and ring and modifications; cube in water; cube in air; coated bulb and modifications; Wendringer; New York Testing Laboratory.

Nearly every laboratory has its own "pet" scheme for this test, and inasmuch as bitumens have no true melting point, because they are mixtures or combinations of many different hydrocarbons and other things, any one of the methods which have been proposed is about as good as any of the others in the hands of a single operator, but no two of them yield comparable results and no one of them in the hands of different operators will agree, unless every detail of the test is scrupulously adhered to.

Ductility.—While at least three different methods for the determination of ductility have been proposed, only one of them is in general use. The three methods referred to are the Dow, Cross and Abrahams, the first mentioned being the most popular. The Cross and Abrahams methods both employ cylindrical test specimens, while the Dow method involves the use of a briquette having a square cross-section at its narrowest part, and taking a flattened hour-glass form.

The results upon the same material as tested by these three methods are not comparable, but some recent co-operative work with the Dow method seems to indicate that results varying from 5 to 4 c.m. were obtained by six different operators upon the same material.

Loss on Heating.—The loss on heating test is one which has been the subject of considerable disagreement chiefly on account of the great variety of apparatus used for the purpose. It would seem to be a very simple matter to weigh out a definite amount of material and expose it in a suitable container to a stated temperature for a stated period of time, but the difficulty lies in the fact that the diameter and depth of the container influence the amount of loss, and the ovens in which the heating is done are of all sorts as regards temperature uniformity and air circulation. During the last couple of years a collection of boxes used by different analysts in making the volatilization test has been assembled. Seven dishes vary in diameter from 4.4 to 7.6 cm., and in height from 1.5 to 4.3 cm. Two have round corners and five have square corners.

Probably the two types of ovens which are in most general use are the New York Testing Laboratory gas-heated, cylindrical oven and the Freas electrically heated, rectangular oven. The former was adopted as standard for this test by the American Society for Testing Materials several years ago, but since that time the Freas and other electrically heated ovens have appeared and are now in very general use.

There is a discrepancy in results in the Freas oven which has been ascribed to the presence of convection currents set up inside the oven. The variation in loss from a number of samples of the same material in one test ranged from an average of 5.8% for position at the front of the oven to 10.4% for position at the back of the oven. The position of the samples in the oven is the chief factor in the cause of the variation. It is obvious that the temperature or the circulation inside this type of oven is not uniform, and that a thermometer in a fixed position will not indicate the true condition of affairs.

In order to circumvent the eccentricities of the oven, a revolving shelf has been devised and installed by Roy Fitch, of the U.S. Bureau of Standards, in the Freas oven in that laboratory. This modification is illustrated in Fig. 1. The shelf is made of a perforated disc of aluminum, and is hung midway in the oven from a vertical shaft which revolves in a fixed bearing in the top ventilator. The samples under test are arranged single file around the shelf and the whole outfit is revolved at the rate of 5 to 6 r.p.m. throughout the entire test. The power is a small 1/100 h.p. motor, geared directly to the shaft. Under these circumstances every sample in the oven is in the same position for the same length of time during test, and two sources of error appear to have been thus minimized, if not entirely removed. Concordant results are impossible if the amount of material, the diameter and depth of the box or dish, and the temperature and circulation of air are not exactly the same in every instance.

Hardening After Heating.—The penetration of the residue after the loss on heating test has been performed is, of course, subject to the same errors as surround that test at all times. It is also affected, however, by the depth of the material under observation, and if this test is to be performed a quantity sufficient to provide proper depth for the purpose should be taken in the beginning.

The maximum depth in millimeters of 20 and 50 grams respectively of a few of the bituminous materials used in road building, in boxes of different diameter, is as follows:—

Depth of Material in Heating Dishes of Different Diameter.

Diameter of dish.	2.5 inches.		2.25 inches.	
Amount of Material.	20 Grs.	50 Grs.	20 Grs.	50 Grs.
Depth of light flux.	8 m.m.	....	20 m.m.	50 m.m.
Depth of heavy flux.	6 m.m.	20 m.m.	9 m.m.	23 m.m.
Depth of 1.25 Sp. Gr. A.C., (50 Pen.)	5 m.m.	8 m.m.	6 m.m.	16 m.m.
Depth of 1.08 Sp. Gr. A.C., (50 Pen.)	6 m.m.	16 m.m.	7 m.m.	18 m.m.
Depth of 1.08 Sp. Gr. A.C., (140 Pen.)	6 m.m.	16 m.m.	7 m.m.	18 m.m.

As 20 grams of asphalt cement in a dish 2½ inches diameter is but 6 to 7 m.m. deep, or the equivalent of 60 to 70 penetration, it is obvious that such material cannot lose the amount permitted by many specifications in the heating test and still be of sufficient depth for the penetration test. The fact that the needle strikes and stops upon the bottom of the dish is not always appreciated and has led to controversy or unfavorable criticism in some instances.

There are a great variety of instruments available for indicating the viscosity of bituminous materials, and while no particular type has been officially adopted for testing road materials, the "Engler" is more generally used for that purpose than any other. In addition to the Engler, the Lawrence, Redwood, and Saybolt, are sometimes mentioned in specifications for road building materials.

None of these instruments speak the same language, but there is no reason for disagreement between different operators or laboratories with the same type instrument, if the standard directions for its operation are observed by both sides.

The relation of several of the more widely employed viscosimeters to each other has been worked out and published in the Proceedings of the American Society for Testing Materials.

Cementitiousness.—The direct determination of the cementitious properties of bitumen has been attempted by different investigators in a variety of ways, and a recent form of such test which is applicable to road surfacing oils is the Osborne test, devised by Clarence B. Osborne, chemist for the State Highway Department, California, and applied in the examination of the heavy oils or liquid asphalt used extensively in that State.

The Osborne apparatus is illustrated in Fig. 2. It consists of a horizontal hollow brass spindle 2 in. diameter by 3 in. long, through which water at 77° F. is circulated, a brass collar 2 in. long by 2.01 in. inside diameter, which fits loosely over the spindle, and a 3-kilo weight attached by a cord to an eye on the collar. The brass spindle and inside of the collar are coated with the oil under examination, and the latter is then slipped over the spindle. The cord holding the weight is wrapped about the collar and when the weight is released the time elapsed in seconds while the collar makes three revolutions is recorded. Results can be checked within a few seconds and the more cementitious materials interpose greater resistance to the movement of the collar than less cementitious ones of the same consistency. As this device is arranged at present, it is not available for testing and semi-solid bituminous cements or binders for macadam type of construction. A series of tests performed in the writer's laboratory upon a number of heavy oils of about the same consistency available in the east gave the following results:—

Heavy Oils.	Osborne Test.
1	770 seconds
2	600 "
3	250 "
4	175 "

The more solid bituminous materials are tested for adhesive properties by several experimenters by cementing two brass cylinders, or prisms, having an area of one square inch, together with as little of the hot bituminous material as will remain between the parallel faces of two such metal sections when a regulated amount of pressure is applied. After adjusting the temperature of the test piece so prepared, the cylinders are pulled apart in a suitable apparatus, such as a tensile machine for breaking briquettes of hydraulic cement. A large number of tests of the same material must be made to secure a fair average, and abnormally high and low results should be discarded. Variations amounting to several hundred pounds frequently occur.

A test of this character is employed by G. P. Homstreet, of the Hastings Paving Company, in the control of the manufacture of asphalt blocks, and also by Dr. Kleeberg, chemist, Bureau of Highways, Borough of Manhattan, but the specifications of municipalities for paving materials have not, so far, included such a requirement.

Brittleness.—A test for brittleness is not usually mentioned in connection with bituminous road building materials, but is in use by some investigators for special purposes. One type of such a test is performed at some specific temperature by resting a small prism of the bituminous material upon knife edges standing a definite distance apart, and striking it midway with a ball weight falling a prescribed distance. This test was probably devised in the asphalt laboratory of the District of Columbia.

Another type of test for brittleness is in use in the laboratory of the Highway Department, State of New York, and elsewhere, and is applied to semi-solid bituminous material of a considerable range of consistency. In carrying out the test, six or eight cylinders, 1.25 or 2.00 inches diameter and of equal height, are cast in a split mold and after they are adjusted to a standard temperature, usually 32° F., are removed from the mold and broken under a Page impact or similar machine. A large number of individual tests upon the same material is necessary to arrive at a fair average.

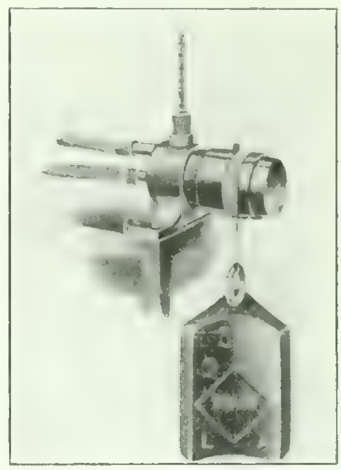


Fig. 2.—Osborne Test for Direct Determination of Cementitiousness.

Solubility.—Bituminous materials are tested in a variety of complete and partial solvents with certain objects in view. The universal solvent for bitumen is carbondisulphide, and bituminous materials and mixtures are therefore treated with that solvent for the purpose of ascertaining their bitumen contents. The bitumen contents of such materials is that portion which is so soluble. Bensole and chloroform are also complete solvents for bitumen, and are sometimes employed for that purpose, but carbondisulphide is in more general use and has wider approval. Carbontetrachloride does not always dissolve as much of a bituminous material as carbondisulphide.

Petroleum naphtha, acetone, and ethyl-ether are only partial solvents of bitumen. The former has been employed extensively in the examination of bituminous materials, but the test is subject to wide variation in the hands of even an experienced analyst, unless the temperature of the solvent, its gravity or limits of boiling point and general nature are collectively always the same.

The results of solubility tests of a given bitumen in 70° naphtha and 80° naphtha are not comparable, nor are the results the same in duplicate tests if one naphtha has been derived from a paraffine oil and the other from an asphaltic oil.

The solvent action of ethyl-ether upon a given bitumen is constant regardless of temperature and, as ethyl-ether is a definite chemical substance having a definite boiling point, the only precaution necessary in the use of that solvent to insure positive results is to employ pure ethyl-ether. (A common impurity is ethyl alcohol.) The same thing is also true of acetone or any other definite chemical substance. There are no limits to the possible variations in such tests if the solvents employed are impure or the tests are performed in a careless manner.

Conclusion.—It has been stated that "the ultimate utilization of tests for the purpose of selecting material for a given use makes it necessary that (1) the test limits adopted shall specifically define the material, and (2) that the material thus defined shall have previously proved satisfactory for that particular purpose."

Under the above circumstances, it is obvious that such tests as have just been discussed do not *per se* disclose the quality of a bituminous material for any specific purpose. The characteristics determined by such tests are usually common to all bituminous substances, good, bad and indifferent.

One will only differ from another in degree, and the extent of such differences, in view of the limitations of the tests now in use, will depend a great deal upon the experience and skill of the analyst making them. With very few exceptions, none of the tests are conclusive, nor the data as a result of their application even instructive, unless it represents a large number of observations upon the same material. Freak results are often encountered and such should be eliminated in computing the average result of any tests susceptible of producing freaks.

The drift of this subject during the past few years rather brings us abreast with the fact that a great deal of attention is being paid to the testing of an element which forms but a small part of an article of manufacture, *viz.*, the pavement in place and ready for work, which might perhaps be devoted, with the hope at least of more positive results, upon the finished article as a whole. The bituminous binder employed in road building is modified to such an enormous extent by the mineral aggregate with which it is associated that its suitability or its quality for any specific purpose cannot be estimated without consideration of the mineral aggregate, and the conditions of service which it is required to meet.

The amount of laboratory work required to ascertain whether a material does or does not comply with such specifications is small, and the question of mere compliance is much simpler and of less actual importance than that of quality.

Bituminous pavements which are put down in sheet form; *i.e.*, as a unit, do not lend themselves readily to testing as a whole or as a complete mixture, but it is obvious that a series of tests which could be applied to the finished article of manufacture, *viz.*, the whole mixture or the pavement in place, would be much more conclusive and satisfying from the point of view of the engineer who is responsible for the work, than the type of tests now in vogue, confined as they are to the raw materials as separate units, and give no direct information as to how congenial such raw materials will be after they are combined.

There is a definite understanding on the part of engineers as to the function of a bituminous pavement, and it would not be a difficult matter to forecast rather closely the probable punishment it will receive in service. A series of tests which could be applied to the finished pavement or to the complete mixture which is to form the pavement would be of infinitely more value to the engineer than any information developed by present-day procedure.

The manufacturer of a pavement must know what raw materials to bring together to produce the results demanded by the purchaser of his product, but at the present time the limitations of results of tests of bituminous materials for road building are such that after the results are obtained the purchaser of the finished article must still select the bituminous material for use therein by reputation for good service.

RIGHTS OF CONTRACTOR UPHELD.

At Montreal recently the Superior Court decided a suit which will be very interesting to engineers and contractors. According to the evidence, Geo. W. T. Nicholson, contractor, of Montreal, took a contract late in 1909 to build a power plant for the Canadian Light and Power Co. Under the terms of the contract the payments were to be made monthly on the engineer's certificate and final payment within 30 days after completion and acceptance of the work.

When the work was partly completed, an official of the company saw a chance to save money by inducing the contractor to consent to a change regarding the measurement of material. The official knew the contractor was hard-up for money and the men's pay was four days overdue. The company itself was behind with payment on the monthly estimate, then due. Knowing this, the official induced the contractor to sign a letter agreeing to a change in the method of measurement, threatening that otherwise the company would further withhold payment of the monthly estimate. The engineers of the company, when the letter was shown them, protested that such a change in the terms of payment was unfair to the contractor. It was also established to the court's satisfaction that by the terms of an agreement made between the company and its engineers at a later date, the engineers became mere servants of the company and not independent certifying engineers. Under instructions from the company the engineers refused to sign a final certificate on the completion of the work, and the contractor was thrown into bankruptcy.

The judge said in his decision: "The engineer was unable to preserve an attitude of judicial independence between the parties, and this released the contractor from all conditions in his contract with the company by which he had submitted to have his rights determined by the engineer." The facts in the case were established not only by the evidence of the plaintiff, but by the engineers themselves. Under these circumstances the court gave a sweeping decision in favor of the contractor, pointing out particularly that the agreement extorted from the contractor to consent to a change of measurement was an agreement obtained by "coercion, violence and fear and was therefore null and void."

A NON-CORROSIVE ALLOY.

A metal that will not corrode on exposure to moisture is very desirable for many purposes, such as for making faucets and other water fixtures, and fittings for yachts, and many alloys have been devised for the purpose, as no simple metal appears to meet the requirements satisfactorily. A new alloy that is claimed to be entirely non-corrosive has been recently patented by an American inventor, consisting of 82 parts of aluminum, by weight, 12 parts copper, 5 parts cadmium and one part silver mixed in a special manner. This alloy is said to be much lighter than copper or bronze, of good strength and to run well in casting.

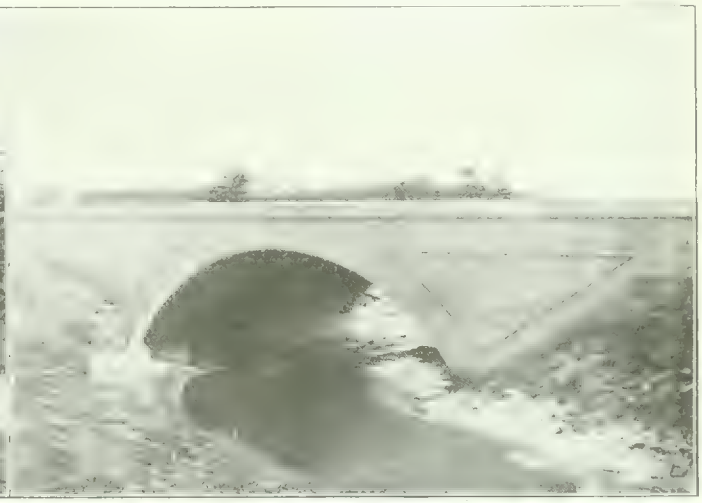
CONSTRUCTION METHODS ON THE TORONTO AND HAMILTON HIGHWAY

By H. S. VAN SCOYOC, A.M.Can.Soc.C.E., A.M.Am.Soc.C.E.,
Chief Engineer, Toronto and Hamilton Highway Commission.

[Mr. Van Scoyoc's paper was fully illustrated by numerous lantern views and a motion picture film. In his introductory remarks he announced that 30 miles of the highway were graded, with practically all the culverts and bridges widened or replaced, and that approximately 17 miles of the concrete highway were open to traffic.—EDITOR.]

THE highway follows previously existing roadways with the exception of diversions at Bronte and Heeks Corners, a slight shifting of location on Water Street in Burlington, and a short stretch of new construction west of Maple Avenue in Burlington. The minimum width of graded roadway is 26 feet. This width has been increased on the highest fills. A minimum of 30 feet was graded in cuts. Culverts and bridges have a minimum clear width of 26 feet. In the towns and villages these widths have been increased to provide for one or two sidewalks, as was felt necessary. The smaller culverts in the heavier fills have been made of such a length that the slopes of the fills are carried out to the regular width, avoiding high end and wing walls. The structures have been designed for the loading specified in Class "C" bridges standard General Specifications for Concrete Highway Bridges, Ontario.

Completed Section.



Concrete Culvert.

The problem may be considered as comprising (1) the handling of materials already on the road in the grading operations, and (2) the handling of materials from outside sources to the road; more particularly those required for the concrete paving. Modern highway building is largely a transportation problem. As illustrating this, more than 90% of the cost of the sand that went into the work under consideration represented handling and transportation charges.

In those sections where there were the remains of macadam roadways the first operation was to tear up the subgrade for at least the width of the concrete by means of a scarifier hauled by a gasoline tractor. In most cases the full depth of stone was loosened by one trip but occasionally more than one was necessary. No difficulty was experienced where bituminous macadam was encountered. The loose stone was moved to the side to increase the width of the subgrade, or to be utilized for shoulder construction, or backfilling by means of a grader, unless the cut was so heavy that the material had to be moved some distance. Pick plows or rooters drawn by horses were used to keep the material loose and the earth hauled by slushers, wheel scrapers or dump wagons, as the distance demanded. If a steam shovel had been near at hand it could have been used to good advantage on some of the Lorne Park hills, but the limited yardages in any one location did not seem to justify the purchase or rental of this kind of equipment. The slopes, both in cuts and in ditching, were hand-trimmed, which added considerably to the cost per cubic yard of excavation, but was necessary if the section was to be maintained. The slopes were made 1½ to 1. Practically all of the removing of sod was done by hand, although graders were used to some extent. Where possible, part of the ditching was done with slushers, but much of it was hand-work. About five miles of trenching was excavated by a trenching machine. While the limited quantity and the nature of much of the soil trenched did not present ideal conditions for low-cost work, a considerable saving was effected in the actual excavation and a much larger saving made indirectly by the reduction in the quantity of material required for backfilling. Practically all of the subgrade was rolled after the rough grading was completed and many of the fills were rolled while being made. The stakes to which the side forms were set were utilized for fine grading. In fact, much of the fine grading was done after the side forms were in place. The Commission's industrial railway track added somewhat to the difficulty of fine grading. This work cannot be too carefully done, for not only does an even subgrade greatly reduce the danger of cracks but it insures the proper thickness of concrete at all times

Industrial Railway.

Buckeye Ditcher Used to Dig Ditch for Tile Drain Adjacent to Sidewalk.

and prevents unnecessary waste of concrete. In all cases the subgrade was carefully rolled just previous to the depositing of coarse and fine aggregate for the concrete.

Yards, Transportation Plant, Etc.—The original plan required three material yards at Port Credit, Oakville and Burlington respectively. Unforeseen difficulties and delays prevented the carrying out of this scheme, and yards were actually located at Waterdown, Oakville and Port Credit. An additional yard will likely be required for the work in York County. Existing sidings on the Hamilton Radial Railway at Port Nelson and on the Grand Trunk Railway at Gooderham Siding, near Clarkson's, were utilized. The sand and stone for the portion of the spur line east of the Grand Trunk Railway crossing was unloaded by hand at Burlington Junction and hauled by team. Practically all the sand and stone at Waterdown, Oakville and Port Credit were unloaded by locomotive cranes with clam-shell buckets and were hauled to the roadway by the locomotives and dump cars on the narrow-gauge track. The materials at Port Nelson were unloaded by hand and hauled by dinkey and dump cars. The materials at Gooderham Siding were unloaded by hand into dump cars, but the dump cars were hauled on the industrial railway by teams. Usually solid trains of sand or stone were hauled.

Where the concrete was 18 feet in width one dump of sand and two of stone met the requirements exactly. The track was first laid to the north of the centre line of the highway, one dump of sand and one of stone made; the track then shifted to the top of the stone pile and the second dump of stone made. As a rule, the cement was delivered after the track had been shifted to the top of the row of stone.

In addition to any economy that industrial railways may effect in actual transportation they are desirable be-

Finishing Pavement from Steel Bridge—Span, 50 ft.
Finishing Pavement from Bridge—Span, 18 ft.

Steel Forms and Form Set-up to Support Felt Expansion Joint.

cause they avoid any necessity for disturbing the subgrade after it has been prepared for the concrete.

For a limited period three mixers were supplied from the Oakville yard. Two locomotives were used and the outfits worked double shifts. The sand and stone were shovelled from the subgrade into wheelbarrows and dumped into the skip of the mixer.

Most of the water required was pumped from Lake Ontario and distributed through a two-inch pipe line.

Steel side forms have been used for practically all of the work so far except for the special work in Oakville. They have proven very satisfactory.

Proportioning has been done by wheelbarrow measurement, a wheelbarrow load having been established by measuring boxes. The concrete remained in the drum for at least 45 seconds and was deposited on the subgrade by means of a boom and bucket. Levelers with spades and hoes distributed the concrete. A strike-board resting on the side forms was used to secure the proper crown and two men working from a bridge finished the surface with wooden floats. The finishers also rounded off the edges of the roadway with edging tools and were responsible

Austin Mixers Working Side by Side on Main Street, Oakville. Roadway, 50 ft. Wide. Full Width of Pavement Carried Forward at Once.

for the workmanship at the joints. The joints were made of felt and were placed every 35 feet. The felt was held against a joint-board with pins until concrete had been placed on both sides of the joint. The board was then removed carefully so that the joint remained perpendicular, the felt extending above the surface of the concrete. A special tamper was used to consolidate the concrete. A divided float prevented one side of the joint from being left higher than the other. The fresh concrete was protected by means of tarpaulins just as soon as the floating was completed. On the following morning the tarpaulins were removed and an earth covering at least two inches in thickness applied. The earth was kept damp by frequent sprinkling for at least ten days. The road was not opened for traffic until the concrete was at least 21 days old. The joint material was cut off flush with the finished surface by means of a sharpened spade.

The earth covering provided part of the shoulder material, the remainder coming from the ditches.

(In concluding, Mr. Van Scoyoc observed that if no unforeseen difficulties arise construction work should be completed this summer.)

WATER DISINFECTION IN CANADA AND THE UNITED STATES.

GENERAL practice in the use of hypochlorite and liquid chlorine in the disinfection of water supplies is the subject of a paper presented recently at a meeting of the American Waterworks Association, by Mr. Francis F. Longley, of the firm of Hazen, Whipple and Fuller, New York City. The statistics contained therein are based upon solicited replies from 110 plants in Canada and the United States, aggregating over 2,000 million gallons per day.

The newer methods of sterilization, *viz.*, ozone and ultra-violet rays, are not dealt with, unfortunately, but Mr. Longley explains that the replies contained very little information in relation to them—not sufficient to warrant its inclusion with that of the hypochlorite and liquid chlorine methods.

According to the replies received, about 80% use, or have used, hypochlorite of lime, and the balance liquid chlorine. About 75% of the supplies regarding which information was received are river waters; about 20% are from lakes, and the small remainder are ground waters.

Of the total installations regarding which replies were received, the percentages installed each year have been as follows:

1909, 13%, representing a total of 100 mil. gals. per day
1910, 14%, representing a total of 450 mil. gals. per day
1911, 22%, representing a total of 320 mil. gals. per day
1912, 22%, representing a total of 710 mil. gals. per day
1913, 18%, representing a total of 70 mil. gals. per day
1914, 8%, representing a total of 265 mil. gals. per day

Some 37% of the cities replying use a disinfection without other treatment. The balance use it as an adjunct to some treatment, in most cases filtration. In 57% of those cases in which it is used as an adjunct to filtration, it is used as a final treatment. In 26% it is used after coagulation or sedimentation and before filtration. In the remaining 17% it is applied before coagulation and filtration.

The data at hand do not give any reasons for the application before coagulation. In general, an effective disinfection may be secured with a smaller quantity of hypochlorite if it is applied after rather than before filtration. It should be noted that the storage of chlorinated waters in coagulating basins and their passage through filters tend to lessen tastes or odors contributed by the treatment, and this fact may in some cases account for their use in this way. Beyond this there is nothing in the moderate amount of bacterial data secured in connection with this work that enables us to generalize upon the relative advantages of these different points of application.

The cost per million gallons for the equipment required for this treatment varies widely and does not seem to bear any very close relation to the capacity. The cost per million gallons as stated, varies all the way from $4 to $2,400. These variations are accounted for by the fact that designs for equipment of this sort vary widely. Some are the merest makeshifts, while others are elaborate. Some of the costs quoted include no building costs, while others include expensive structures. Taking the figures as they stand, as the data do not permit any further analysis, the total costs per million gallons are stated not to exceed $25 in 12% of the supplies, $50 in 30%, $100 in 42%, $250 in 67% and $500 in 87% of the supplies about which information is available.

The total cost per million gallons for the process also varies widely. By far the greater number of costs stated lie between 10 cents and 50 cents per million gallons, the average for these being about 25 cents.

The information at hand indicates that the commonest construction of tanks for hypochlorite is concrete. Some 67% of the replies stated that they had either concrete tanks or tanks of wood or iron relined with concrete. Something more than 20% are of wood without lining. The balance are either wood with lead lining, wood or iron with some protective or acid-resisting paint, or porcelain lining. The liquid chlorine is universally contained in special iron cylinders.

The piping seems in general to have been put together of the materials most easily available, without regard to corrosion. Fifty-six per cent. of the replies indicate the use of iron pipe, either block or galvanized, 15% use lead pipe and about an equal number use brass. A few use lead-lined iron pipe, cast iron pipe, hard rubber, rubber hose, bronze or copper pipe.

The same comments apply to the kind of valves and fittings commonly used. Sixty-six per cent. of these are of brass such as are usually found in stock. Some 14% state that bronze valves and fixures are used, but it is possible that some, if not most of these, upon further inquiry, might prove to be brass. A few use iron valves or fittings and a few have fixtures made of vulcanite, rubber composition, lead, copper, glass, etc.

The materials commonly used which seem to have shown the greatest resistance to the corrosive effects of hypochlorite are concrete tanks, lead pipe and rubber composition. Several of the answers indicate that copper, cast iron and lead-lined iron pipes are used without corrosion and a number indicate, too, that brass and galvanized iron are used without corrosion. The evidence as to these two last materials, however, is contradictory, as other answers indicate considerable corrosion with galvanized iron and brass. It seems likely that the quality of the material and some peculiar local conditions may, perhaps, be determining factors in the corrosive effect upon these two materials. The results show the unmistakable corrosive effect upon wrought iron and also upon wood.

Evidence has been found in the past of occasional large variations in the strength of commercial hypochlorite. In answer to an inquiry on this point, only 29% indicated that the strength of hypochlorite as purchased had been determined. That this is a point of considerable importance is indicated by the following figures:

The maximum percentage of available chlorine stated was 42%. Numerous others ran as high as 39 or 40%. The minimum stated was 15%, with several others less than 20%. The average strength was 33%. In two cases the maximum percentage strength noted is as large as 2½ times the minimum strength. These variations in quality in the commercial hypochlorite are significant, and it is obvious that the strength should be determined and a correction made in the application, if necessary, if the best results are to be secured.

The low cost and the ease of application of disinfection to water supplies have caused its introduction in a great many places where the records of mortality or morbidity from such diseases as typhoid, which can be used as indicators of the benefits derived, are already so low that no striking improvement can be expected therein. In a large percentage of the cases it seems clear that the application was as a precautionary measure. This fact makes it less easy than might be expected from the large number of cities and towns making use of disinfection to present statistics showing actual benefits resulting therefrom. Among the large number of communities from which information was obtained, about 75% failed to indicate that any improvement in typhoid or other health condition had resulted. In some cases where there has been an improvement it is difficult or impossible to discriminate between the effects of disinfection and of filtration. Mr. Longley summarizes a number of reports, however, to show the improvements that resulted in various places.

Judging from the lack of information in response to inquiries bearing upon the relation between the quantity of hypochlorite required and the color or turbidity in the water, it seems that a surprisingly small amount of attention is given in the various cities to following out this relationship. A knowledge of this relation is of some importance, as it influences the quantity of hypochlorite that is required for a given water, the quantity that may be applied without producing objectionable tastes and the economy of the treatment.

The reason for the lack of attention to this point seems to lie in the fact that the cost of the hypochlorite required for any water is trifling and it is not of great importance just what quantity is applied, so long as it is enough, on the one hand, to give good bacteriological results, and, on the other hand, not so much as to produce objectionable tastes and odors.

The doses that fulfil these two conditions do not always coincide. The character of some waters is such that the dose which can be applied without contributing objectionable tastes and odors is more than enough to produce the desired bacterial reduction. With such waters there is no difficulty in regulating the dose to give satisfactory results from every point of view. The character of other waters is such that the maximum dose which can be used without giving a taste is not enough to give the bacterial reduction required. This is the difficult condition to meet, and is found more frequently in raw waters than in filtered waters.

It is everywhere recognized that there are certain times when the hypochlorite treatment is less satisfactory than at others. This is shown principally in the appearance of tastes and odors that occasion complaint among consumers, or in a low and unsatisfactory removal of bacteria by the treatment. It occurs generally at a time when the turbidity or the color of the water increases greatly, or some other marked change, such as temperature, occurs in the condition of the untreated water.

Different waters vary a good deal in this respect, and but little information can be found which gives light upon the specific reasons for this variation and permits the formulation of general statements in regard to it.

An analysis of the figures at hand shows that in one place a maximum dose as great as 37 pounds per million gallons has not given rise to objectionable tastes or odors, and in numerous places 20 to 30 pounds has not been noticeable. The average amount stated for which no odor or taste was noticed was about 14 pounds per million gallons. The replies in which it was definitely stated that no tastes or odors were noticeable included about 40% of the total. Among the others there were general comments as to the occurrence of objectionable tastes or odors, indicating in the main that they are likely to occur with changes in the character of the water treated, especially at times of storm or freshet.

So far as is indicated by the somewhat incomplete data, the largest quantities of hypochlorite are used in those supplies in which the color or turbidity of the water are highest. Unfortunately, the information is not complete enough to enable any relationship to be established even in an approximate way between color, turbidity and quantity of disinfecting agents that may be used without objection.

COUNTRY ROADS.

By W. Muir Edwards,
Professor of Civil and Municipal Engineering,
University of Alberta.

IN dealing with country roads it might be well to first point out that the use of material other than that found in the neighborhood is generally financially out of the question. Whether it be loam, sand or clay the local conditions must be dealt with and the road constructed of material at hand. In the second place, we should emphasize the fact that, although there are locations in which physical difficulties may be met which are hard to overcome, most country roads could be made quite satisfactory by a moderate expenditure of labor and oversight. Drainage, proper initial construction and continuous upkeep are the essential features.

In discussing road construction, too much importance cannot be attached to proper drainage. As we travel the country roads, possibly no feature is so noticeable as the almost uniform practice of repeatedly filling in bad spots which could be permanently cured by much less labor devoted to proper drainage. In road construction we deal with surface, side and subsoil drainage.

Surface drainage of the roadway is very important. The most destructive agent which the road has to contend with is water, if allowed to remain any length of time in its neighborhood. If pooled on the roadway the top surface is softened and under the action of the traffic the road is rutted. These ruts hold more water and if conditions are not speedily remedied the roadway goes from bad to worse until it is almost impassible. Just here attention might be called to the fact that the criterion of a good road is not the possibility of finally passing over it with a load, but rather that such a surface is maintained that the motive power, be it oxen, horses or motors, shall give a reasonable return on the capital it represents.

Surface drainage is accomplished by crowning the road. The slope from the centre to the sides should be varied to suit the material used. From one-half inch to one inch of fall per foot of road width measured from the centre will give satisfactory results. Too flat a crown tends to poor drainage, whilst too steep a side slope may rut the roadway and also will encourage undue traffic on the centre portion. This "tracking" of vehicles means increased wear at one spot and is a frequent source of destruction to the roadbed.

Having shed the water to the side of the roadway, it is equally important that arrangements be made for the satisfactory progress of this water in the roadside ditches. Although the slope of these ditches may be fairly flat, the water should flow to a definite outfall and so be carried away from the neighborhood of the roadway. It might seem quite unnecessary to emphasize such an obvious matter as an outlet for the side ditches but, strange to say, this feature is totally neglected in many pieces of roadwork. Due to the soakage of water from these blind ditches into the body of the roadbed, bad spots are developed which last long into dry-weather periods.

Subsoil drainage is often necessary where the road runs across low, wet land. If the surface of the subsoil water can be lowered, a firm foundation for the roadbed may be obtained. Drainage of this type is usually quite expensive and in many cases may be classed with bridges and other permanent provincial undertakings. Another type of subsoil drainage is that of the roadbed itself. Tile drains are placed on one or both sides of the roadway at a depth of 2½ to 3 feet below the surface. The moisture in the roadbed is drawn off, thus increasing its bearing power and lessening the effect of frost action. In the clay soils so prevalent in the Province of Alberta this type of work is of questionable utility. In sand roads it would be distinctly harmful, since a sand road is the one exception to the general rule regarding drainage. The retention of the moisture is the feature to be aimed at in the operation of such a road.

Initial construction and drainage are so closely connected that a discussion of one must include the other. Without, therefore, devoting any further space to the first two essentials in road building, we might consider the third, which applies more particularly to road operation. Upkeep should be given equal prominence with drainage in any roadway discussion. The filling-in rather than the drainage of bad spots has already been commented upon as the most noticeable feature of poor roadwork. This should really be qualified and possibly the premier place given to the practice of industriously grading a roadbed and then cheerily leaving it to look after itself. Earth roads especially need care if they are to remain in a satisfactory condition. This care may be of the simplest kind, consisting of the cleaning of roadside ditches and the dragging of the roadway. This latter operation consists of pulling over the road a drag which fills in the ruts, smooths out the ridges and recrowns the road by moving material from the side to the centre. The drag itself is extremely simple to construct. Any blacksmith shop or well equipped farmer's workshop could turn one out for not more than $15. The cost of the operation is also by no means excessive. Owing to the character of the spring and fall seasons in Alberta, and since no work is required during the winter, an average of $10 per mile per year should cover all that is necessary in dragging operations. This is equivalent to a charge of $3.75 per quarter-section for this part of road maintenance. Considering the saving to the farmers in actual cost and the convenience and comfort to be derived from good road connections with the nearest town and with the neighborhood generally, it might well be considered that it is inertia and lack of knowledge rather than the expense involved which prevents the practice. In dragging lies the secret of the proper maintenance of serviceable country roads.

The necessity for the proper placing and proportioning of culverts might very well be dealt with, but space permits only a reference to the matter.

Grading an earth road can be done for less than $150 per mile; maintenance, including dragging, might be placed at $15 per mile per year. It is quite possible that additional expenses may be found to be justified in surfacing country roads with a judicious mixture of sand and clay. The discussion of this might be left to be considered in dealing with more expensive types of roadwork justified in highway construction, and will be dealt with later.

The United States Senate has before it the Shackleford Bill, sent on by the House of Representatives, carrying an appropriation of $25,000,000 to aid the states in improving their public roads.

A convention of branch managers of the Trussed Concrete Steel Company was held on January 25th-28th, at Youngstown, Ohio. Representatives attended from all over Canada and the United States, and also from Japan, Hawaii, South America and Porto Rico. Among the papers and discussions were some on steel sash, reinforced concrete, shop practice, engineering practice, commercial value of engineering service, experiences with reinforced concrete, metal lath, concrete pavements, Kahn mesh reinforcement, history and growth of the company, etc.

HOW LONG WILL OUR TIMBER LAST?

By R. H. Campbell.

The question is frequently asked, "How long will the present supply of commercial timber last in Canada?" Estimates made have varied from 50 years to 300, depending on the basis of the estimate. As a matter of fact, Canada is not facing an immediate timber famine and the existing supply, if properly utilized, would last indefinitely.

The method of making these estimates shows their uselessness. If we assume that the present supply of material is 600,000,000,000 feet of saw timber and the annual consumption 5,000,000,000 feet, it is easy to see that the supply will be exhausted in 120 years, providing that the supply is not reduced except by regular lumbering, and that the annual consumption remains unchanged. These are the most important conditions, but the question also depends on changes in prices, extent of importation and exportation of lumber, use of substitutes and new uses of lumber itself.

It has been estimated that forest fires destroy more lumber annually than is cut and sawn by lumbermen. This is one of the most important variables in the equation. The annual production of sawn lumber increased up to 1912, then decreased in 1913 and in 1914 has increased again. It would be absurd to depend on this fluctuating factor in making calculations to cover the next century or more. If the increase in production of lumber were regular and equalled 200 million feet the supply would be exhausted in about 50 years, instead of 120 years. As prices of certain classes of lumber in Canada increase other cheaper woods are imported from the United States. The present war and the closing of the Baltic ports has created a demand for Canadian timber in Great Britain and France hitherto supplied by Russia and Sweden.

The use of metal and concrete in building construction, bridges, culverts, harbor works, etc., has reduced the demand for wood for these purposes, but has increased the demand for lumber for concrete forms, templets, foundry boxes, patterns and wood used in connection with mining and marketing metal products. The pulp industry which consumed an equivalent to one billion feet of lumber in Canada in 1914, is a new industry, using wood to an extent which could not have been foreseen 25 years ago. These various considerations demonstrate the futility of estimating the probable date at which our supply of lumber will have been exhausted. While we should not sit back complacently and say, "The supply is good for 300 years; let posterity look after itself," it is equally wrong to take the pessimistic attitude that we are facing an immediate wood famine.

The available statistics concerning forest products show the natural course of events. In January, 1900, the price of "white pine, good sidings" in Ottawa was from $33 to $38. The same material in 1914 was listed at $58 to $65. This is an increase of $26 per thousand in 14 years or about $2 a year. This is the best grade of white pine; the average price of white pine lumber of all grades in 1908 was $20.03. The average price in 1913 was $20.79, an increase of only 76 cents in five years or an average increase of 15 cents a year. In the last five years the average price of lumber has increased slightly compared to the increase in the value of the best grades. This means that there has been an increase in the production of the poorer grades of lumber. Logs are sawn to-day and used in making boxes, rough construction and other inferior uses that would have never been cut under the wasteful logging methods in vogue 20 years ago. This closer utilization, the use of inferior lumber for inferior uses, is a form of conservation that tends to postpone the final exhaustion of the lumber supply. It is through such forms of conservation as these that we can hope to postpone this exhaustion of supply indefinitely.

Forest fires destroy millions of dollars worth of standing timber annually; they can be prevented by proper precautionary measures. Wasteful logging methods are rapidly being superseded as the price of lumber increases. Closer utilization of all material is a form of economy. The use of substitutes wherever possible usually reduces the unnecessary consumption of wood. The use of inferior species or trees which have been considered as weeds, for purposes to which they can be adapted, reduces the consumption of more valuable materials. Finally the planting up of waste lands, burned-over or logged areas and all lands not fit for agriculture, paves the way to intensive forest management, when the forests of the country will yield an annual crop of wood equal to the demands of the country for all time.

Canada has a great national heritage of timber resources. The existing supply of commercial saw timber lies between five and seven hundred billion feet, board measure, and covers an area of approximately 170,000,000 acres, the greater part of which is land unfit for agriculture, but suitable for producing timber. There are over 150,000,000 acres of forest reserves in Canada, much of which does not carry timber of commercial value at present, but all of which is capable of producing valuable forest products.

In 1914, Canada's 2,843 active sawmills reported cutting 3,946,254,000 feet, board measure, of lumber valued at the mill at $15.30 a thousand feet. Spruce, white pine and Douglas fir together formed 72 per cent. of the total. Canada's lumber production consists chiefly of soft woods or the woods of coniferous trees, the hardwoods forming less than 7 per cent. of the total. (In the United States the hardwoods form over 20 per cent. of the lumber sawn.)

Canada produced in 1914, 2,196,884 cords of pulpwood, valued at $14,770,358. Lumber and pulpwood are our most valuable forest products, but the total, which includes firewood, ties, poles, posts, piles, fence material, wood for distribution, tanning material, cooperage stock, and many other miscellaneous products, is estimated at over $150,000,000.

RAILROAD EARNINGS.

The following is the weekly record of the transcontinental railroads' gross earnings for January:—

Canadian Pacific Railway

	1916.	1915.	
January 7	$1,874,000	$1,316,000	+ $558,000
January 14	1,863,000	1,321,000	+ 542,000
January 21	1,910,000	1,391,000	+ 519,000
January 31	2,733,000	1,880,000	+ 853,000

Grand Trunk Railway

January 7	$ 880,702	$ 753,522	+ $137,180
January 14	966,301	779,745	+ 186,556
January 21	980,914	795,830	+ 185,084
January 31	1,459,499	1,091,716	+ 367,783

Canadian Northern Railway

January 7	$ 541,100	$ 315,700	+ $225,400
January 14	469,300	349,300	+ 120,000
January 21	504,000	322,600	+ 181,400
January 31	572,400	451,800	+ 120,600

The Canadian Pacific Railway statement of earnings and operating expenses for the month of December shows an increase in net earnings of $3,502,797, or 159 per cent., over the corresponding period a year ago, total net being $5,702,321. Gross earnings were $12,705,673; working expenses, $7,003,352. For six months ended December 31st figures are: Gross earnings, $66,470,164; working expenses, $36,845,977; net profits, $29,624,187. In December, 1914, net profits were $2,199,524, and for the six months ended December 31st, 1914, $19,673,576.

The Canadian Northern December statement shows the following figures:—

	1915.	1914.	Increase.
Gross earnings	$3,435,600	$1,809,600	$1,626,000
Expenses	2,233,500	1,376,400	857,100
Net earnings	1,202,100	433,200	768,900
Mileage in operation..	8,270	6,886	1,384

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended February 4th, 1916:—

Dominion Reduction Company, 88,000; La Rose Mines, 87,027; McKinley-Darragh-Savage Mines, 170,126; Coniagas Mines, 168,423. Total, 513,423 pounds, or 256.7 tons.

New Liskeard—

Casey Cobalt Mine, 59,090 pounds.

The total shipments since January 1st, 1916, are now 2,888,662 pounds, or 1,444.3 tons.

VALUE OF ONTARIO'S NICKEL

By T. W. Gibson.

Nickel is the distinctive metal of Ontario. Its property of imparting great strength and toughness when alloyed with steel was first made known by James Riley, of Glasgow, in 1889, and advantage was almost immediately taken of this discovery in the manufacture of armor plate for battleships. Its success in this field soon led to its introduction into other departments of war equipment. Other metals there are, such as tungsten, vanadium and molybdenum, which form satisfactory alloys with steel, but all of them are rare, and more expensive than nickel. It would seem that no other element possesses all the qualifications for the manufacture of special steels, intended for military and naval use, in so high a degree as nickel. It is, therefore, not to be wondered at that from the very beginning of the present great war the abundant supplies of nickel in Ontario were regarded as of great, and indeed Imperial importance, since they conferred so marked an advantage on the arms of Britain and her Allies.

No doubt Germany had laid up stores of the metal in anticipation of the present conflict, but when these were exhausted there was little chance of replenishing her supply, since her native sources of nickel and those of Europe generally are few, and yield but scantily. Notwithstanding Germany's need for nickel, it may here be said that the fears expressed in some quarters that she might obtain supplies from Ontario during the war were, and are, entirely unfounded.

But while present conditions bring into prominence the usefulness of nickel for purposes of war, in normal times of peace its properties render it no less serviceable. Wherever strength and lightness are required in steel construction nickel is almost indispensable. It has come largely into use in the manufacture of automobiles, bicycles, marine boilers, propeller-shafts and other articles where a maximum of strength and a minimum of weight are desirable. A striking example of its use is in the new Quebec railway bridge across the St. Lawrence River. The old bridge was too heavy; that is to say, it would have been all right had it been possible to get it into place, but the completed structure succumbed to the strain imposed by its own weight. The admixture of nickel in the steel of the new bridge will at once add to its strength and, by reducing the weight of its parts, lessen the strain.

Nickel is very little susceptible to corrosion, and a mixture or alloy of nickel and copper, in practically the same proportions in which these substances occur in the ore, named monel metal, has been found very serviceable when called upon to resist such agencies as sulphuric or other acids, which quickly eat away ordinary iron or steel. Many other uses for nickel might be mentioned, such as for plating metallic objects, making Britannia metal or German silver, for coinage, etc.

There are two kinds of nickel ore found in Ontario: (1) the nickel-copper ores of the Sudbury district, which are essentially pyrrhotites, carrying chalcopyrite and pentlandite, and (2) the cobalt-nickel arsenides of the Cobalt region are described by A. P. Coleman as occurring in connection with "a single great sheet of eruptive rock, roughly boat-shaped, with a blunt bow to the south-west and a square stern to the north-east." Only the upturned edges of the sheet are exposed, and on the outer edge of this sheet are found the ore masses, which are lenticular in character.

these sources is of comparatively little importance commercially, though it may be mentioned in passing that the first refined nickel produced in Ontario came from the ores of Cobalt. Geologically, the ore bodies of the Sudbury region, whose chief value is in their silver. The second of

A considerable number of mines have been opened since the discoveries were made in 1883, and the ores, though of the same general character, vary somewhat in their metallic contents. The great Creighton mine of the Canadian Copper Company is one of the largest and richest of the mines. It carries about 2 per cent. of copper and 5 per cent. of nickel. The Crean Hill in 1907 averaged 4.84 per cent. of copper and 2.35 per cent. of nickel. No. 2, or Copper Cliff, produced more than a million tons of ore, containing 3.55 per cent. nickel and 3.3 per cent. of copper. The ore of the Evans mine ran about 3 per cent. nickel and 2.66 per cent. copper. Frood is an immense body of somewhat low-grade ore, running about 2.66 per cent. nickel and 1.39 per cent. of copper. The Stobie was also low-grade, and carried 2.13 per cent. nickel and 1.38 copper. The Murray, when worked, produced ore containing about 2.25 per cent. of nickel. Victoria, Blezard, Garson, Elsie, Gertrude, Levack, and numerous other deposits have all contributed to the output of the region. Whistle, Blue Lake and other deposits on the northern range have not yet begun production. Diamond drilling, during recent years, has greatly increased the known reserves of ore; this is true particularly of the Creighton, Frood, Murray and Levack mines, where many millions of tons of ore have been proven to exist.

The nickel-copper industry is expanding rapidly. The output of nickel in 1910 was 18,636 tons, and of copper 9,630 tons; in 1914, notwithstanding the outbreak of the war and the consequent disturbance of the industry, the product amounted to 22,750 tons of nickel and 14,448 tons of copper. For the first nine months of 1915 the yield was 24,054 tons of nickel and 14,057 tons of copper, and, if maintained at the same rate, the production for the full twelve months will be not less than 32,000 tons of nickel and 18,750 tons of copper. Even at the low valuation placed by the companies on the nickel and copper contents of the matte, the value of the nickel output of 1915 will be $6,400,000 and of the copper $2,600,000, or $9,000,000 in all. At the present price of the refined metals these figures would be increased to 20 or 25 millions and 7½ millions, respectively.

The processes employed in mining and treating the ores are well known. After being raised to the surface the ore is crushed and sorted, being afterwards roasted in heaps in the open air to expel the sulphur. It is then smelted in a blast furnace to a low-grade matte, which is immediately converted into a Bessemer matte carrying 75 or 80 per cent. of the metals, say, 50 per cent. nickel and 25 per cent. copper in the case of the Canadian Copper Company, and 40 per cent. each of nickel and copper in that of the Mond Nickel Company. The matte is subsequently exported to Constable Hook, N.J., and Clydach, Wales, respectively, for the final separation of the metals. The refining process employed by the Canadian Copper Company produces refined nickel and blister copper, which undergoes still further treatment before becoming pure metal. In the Mond Company's works the nickel carbonyl method gives pure nickel, while the copper is recovered as copper sulphate, which is in demand in the vine-growing countries of Europe as a safeguard against the phylloxera pest. The two companies mentioned are the only producers of ore, with the exception of the Alexo Company, which operates a comparatively small deposit in Dundonald township, on the Porcupine branch of the Timiskaming and Northern Ontario Railway. The significance of this ore body, which much resembles those of Sudbury, consists in its geographical position, being remote from the better-known deposits.

CANADIAN GOVERNMENT RAILWAY EXPENDITURES.

The Dominion government's expenditures on railways to the end of the last fiscal year was $648,075,427 and on canals $150,205,770. The revenues from railways and canals since Confederation were $222,183,757.

The annual report of the department of railways and canals shows the total expenditure on the National Transcontinental Railway for construction is $152,802,745.

The total expenditure on the Grand Trunk Pacific mountain section approved and certified up to the end of March, 1915, is given as $87,119,153, while $15,556,482 was spent on the prairie section up to the end of October, 1907, no further certificates having been issued for this section.

The total railway expenditure during the fiscal year to March 31st, 1915, was $42,747,532, including the outlay on the Quebec Bridge construction. This total includes $18,101,809 on the Intercolonial Railway, $1,168,757 on the Prince Edward Island Railway, and $10,071,479 on the National Transcontinental Railway.

The canal expenditure amounted to $7,314,131. The total outlay for the year on railways and canals was $50,063,988. The revenue derived from government railways and canals was $12,577,120, including $12,149,357 from railways and $427,763 from canals.

The operation of the Intercolonial Railway for the year resulted in a profit of $42,965 on total earnings of $11,444,873.

CONCRETE PIPE TUNNEL, N.T.R., QUEBEC.

By C. V. Johnson, A.M. Can. Soc. C.E.,
Chief Engineer to Joseph Gosselin, Engineering Contractors, Quebec.

THERE has been considerable discussion, at various times, as to the safety of erecting concrete structures in freezing weather. It seems to be generally recognized at the present time that there is little or no danger in pouring large masses of concrete in cold weather, such as is experienced in this country, provided proper precautions are taken to have the materials well heated and the work protected from the cold in so far as existing conditions will permit. On the other hand, many engineers and architects look with disapproval on the practice of pouring thin walls or slabs during the winter months, and probably with some reason, as more care must be taken, in order to ensure a good job, than is, perhaps, consistent with many contractors' ideas of allowable expenditure.

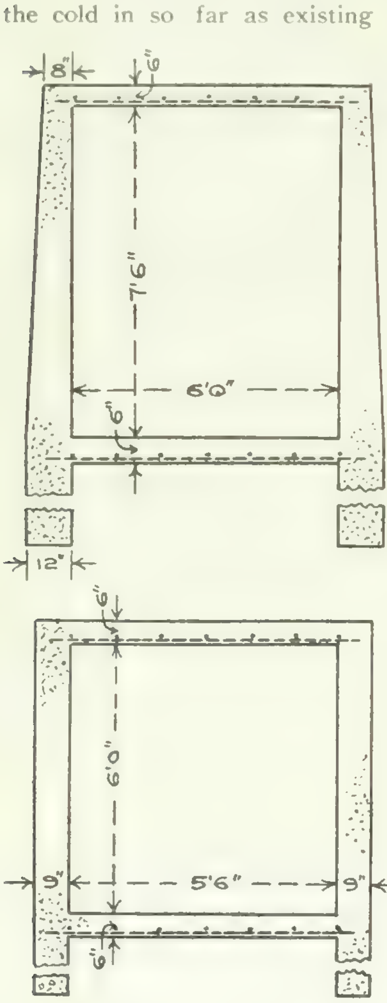


Fig. 1.
Typical Sections of Pipe Tunnel.

It is not, however, the intention of this article to enter into a discussion of this question, but merely to place before the profession an instance which tends to show that, with proper care, thin work may be carried on with equal safety to mass work.

The work in question is a concrete pipe tunnel, partly reinforced, which was constructed in the yard of the National Transcontinental Shops at Quebec. The concreting of this tunnel was commenced on the 20th February, 1915, and carried on almost continuously until the end of April, during which period the mercury dropped considerably below zero at various times. No concreting, however, was done at a lower temperature than 10 deg. above zero, although on one day, during the construction of the reinforced top, owing to a very sudden drop in temperature, the mercury had reached 5 deg. below zero before the concrete was 12 hours old. No ill effects developed from this as ample precaution was taken, by means of sacks and planks, to protect the finished work.

This tunnel, as shown by the accompanying sections (Fig. 1), is of thin construction throughout, the walls at no point exceeding 12 in. in thickness, and the floor and top being a 6-in. slab, reinforced with ½-in. square bars, placed 12 in., c. to c., both ways. The total length is approximately 850 feet, and the sections vary slightly according to the depth required.

The transportation of the concrete to the forms was accomplished by means of barrows, the longest haul being about 300 ft. Two ½-yd. Smith mixers were placed at the most convenient points, together with separate boilers to supply steam for heating the materials to be employed. In preparing the site for the reception of the sand and stone, a line of 1-in. steam piping with half a dozen branches of varying length and with open ends, was placed on the ground at each point where it was intended to pile the sand and stone and the materials dumped over these pipes. In this way it was only necessary to connect up the mains from the boilers, with the ends of pipe projecting from the piles, and turn on the steam, thus ensuring a continuous supply of well-heated sand and stone. A branch steam line was also run to the tank from which the water was supplied to the mixer and the water kept heated. Many authorities claim that it is unnecessary to heat the water if the sand and stone are also heated, but at any rate it accomplishes the purpose of doing away with the inconvenience of ice forming on the tanks and pails, and the small amount of extra steam required is of no consequence.

Fig. 2.—General View, Showing 550 ft. of Trench with Outside Form in Place—(Walls in Background are Ready for Pouring.)

Each night, on completion of a portion or section, of the top of the tunnel, care was taken to protect the finished work with a double layer one 1-in. boards and empty sacks, these being left in place for a period of 48 hours at least. The walls were protected by filling the space between the forms and the side of the trench with snow.

(*Continued on page 291.*)

Editorial

DESIGN OF LATTICE BARS.

The determination of a supposedly indeterminable formula naturally always awakens interest among engineers. Upon consulting the various authorities upon structural steel design, one finds that they all agree that the only formula obtainable for calculating stresses in lattice bars of channel columns are empirical and approximate. *The Canadian Engineer* has great pleasure in presenting this week an article by the city architect of Toronto, who gives a theoretical formula from which results are obtained that agree remarkably well with the few tests that have been made.

Mr. Pearse has decided, after years of work, that this formula is correct and practical. He has not only derived the formula, but he has also put it upon a working basis by compiling a table which will be of great convenience to structural detailers.

Mr. Pearse's name is not an unfamiliar one to steel men, as he has been the author of a number of valuable articles, including one published about two years ago on buckling in the webs of beams. In another article he derived the approximate formula for stresses in lattice bars which has been in most general use during the past nine years.

The new formula is based upon the idea that if the stress in the centre of the column be known, and if a curve be plotted that conforms to the shape that the column takes when bending, and if the centre ordinate be made equal to the stress at the centre of the column, then the stress at any other point in the column must be equal to the ordinate of the curve at the point taken.

It is proven that the curve will be sinusoid. A practical demonstration of this is to take a very thin piece of wood and press upon it at both ends. The strip will then take the form of a sinusoid. This method might be an easy way of plotting the curve after the centre ordinate is known.

It would seem that the formula derived by Mr. Pearse is a distinct advance in the theory of structural engineering, and unless disproven in some way, which is unlikely, it will undoubtedly be used hereafter in the design of all built-up columns.

ICE CONDITIONS IN HUDSON BAY AND STRAIT.

According to the report of F. Anderson, officer in charge of the Hudson Bay survey, the entrance to Hudson Strait is blocked more or less from the last week in November to the first week in January, due to the Arctic current carrying great masses of field ice and icebergs along the east shore of Baffin Land, across the entrance to the strait. The *Acadia* was held up off Cape Chidley from July 19th to 30th by ice packs. On the 31st a gale from the northwest opened out the pack and improved conditions. It would have been possible for the ship to proceed through the strait and enter Hudson Bay at this stage without any more difficulty or damage than would result from remaining in this locality, but as considerable work was to be done in the vicinity of the Button Islands, the ship remained.

In attempting to make the Buttons, it was found that the passage to the anchorage was completely cut off by ice and the ship was caught in heavy tide rips and hemmed in; thus it was clearly demonstrated that ships trying to make the strait should give the Buttons a wide berth.

On the north side of the entrance, however, about Resolution Island, the tidal currents were found just as strong, but the ice appeared to be much lighter.

After doing some survey work on the north side of the entrance, a course was laid for the Button Islands, which were reached with little difficulty. Considerable exploration work was done in the strait and the ship proceeded to Port Nelson, which was reached September 13th. After making surveys in the bay, the ship cleared Port Nelson on October 8th. On the 14th she was held up by an ice pack which, however, opened out next morning when the tide changed. Although the *Acadia* was able to get through this ice without injury, it would have been quite difficult for an ordinary freighter to have done so.

It will be seen from the above abstract of Mr. Anderson's report that he has not made any derogatory statements as to the navigability of the strait, such as he is alleged to have made by certain prejudiced persons who have abstracted isolated paragraphs from his report which are at variance with his deliberately expressed opinion in a previous supplement issued before leaving on his last trip to Hudson Bay. Mr. Anderson then stated that "the period during which properly constructed vessels could enter Hudson Strait with comparative safety may be taken from July 15th to November 15th, with a slight extension at either end, according to the season," which statement was made from observations based on his years of experience and not on this one trip. It is hardly likely Mr. Anderson would allow the difficulties of one season to change his deliberately expressed opinion.

LETTER TO THE EDITOR.

Oil Tar Creosotes.

Sir,—I have noted with interest the editorial comment in your issue of December 30th, 1915, with reference to oil tar and coal tar creosotes. Apart from the discussion of the relative value of these products for various uses in the preservative treatment of wood, the following information regarding methods of analysis and distinguishing tests may be of interest to engineers, inspectors and chemists who are responsible for the interpretation and enforcement of specifications covering the purchase of creosote or creosoted material.

There are certain fairly constant differences in the composition of these products which serve as a basis for distinction by means of chemical and physical tests as indicated below. Typical coal tar creosote is composed almost entirely of the aromatic series, including a proportion of tar acids—phenols and cresols. Typical water gas tar, which is the most important of commercial oil

tars, contains a proportion of undecomposed paraffin oils and is lacking in tar acids.

Fractional distillation of coal tar creosote and water gas tar oil may give very similar results, but it is generally possible to identify the origin of such oils by a closer examination of the composition and physical properties of the various fractions so obtained. Differences in specific gravity and refractive index are the most reliable of the distinguishing physical characteristics. Fractions distilled from coal tar creosote have higher specific gravity than fractions of water gas tar oil distilled between the same temperature limits, and similarly the indices of refraction of the former are higher than those of the latter fractions. The melting point of the higher boiling fractions—those distilled above 320° C.—is also of value as a means of distinguishing between the two products. Oil tar fractions distilled above 320° C. are liquid at 60° C. while corresponding coal tar fractions are rarely liquid at this temperature. Other characteristic physical properties which may serve as a supplement to the more definite tests noted above are the odor and color of the oil fractions. Water gas tar has a particularly disagreeable characteristic odor which can generally be recognized.

The detection of paraffin oils by sulphonation test is probably the most conclusive chemical test for the distinction between coal tar and oil tar products. Hydrocarbons of the aromatic series are converted into soluble sulphonic acids by treatment with concentrated sulphuric acid, and the undissolved residue—paraffin oils—determined by separation. This test is usually made on the fraction distilling between 305° C. and 320° C. A positive result, *i.e.*, a residue of undissolved oils, indicates oil tar origin. The determination of tar acids by hot alkaline extraction is also of value in identifying a creosote sample. Deficiency in compounds of these series indicates that the oil is an oil tar product. However, this test is, perhaps, not so conclusive as the sulphonation test.

The distinguishing tests above described apply to typical commercial oils, but it should be remembered that low coking temperatures, as in certain types of bituminous gas producers or where bituminous coal is used as a blast furnace fuel, yield tars from which creosotes may be distilled which will be very similar to water gas tar oil. Coal tars of this class are, however, of very limited production in America. It must also be noted that the certain detection of oil tar in mixture with coal tar creosote is not always possible, and in cases where the results of foregoing tests suggest the presence of oil tar products, it may be necessary to investigate the history of the sample for conclusive information.

Detailed methods for the laboratory examination of commercial creosotes are outlined in "Preservation of Structural Timber," H. F. Weiss (McGraw-Hill Book Co.), or in publications of the United States Forest Service as noted below. Complete laboratory examination includes determination of specific gravity of the whole sample, fractional distillation, determination of specific gravities and refractive indices of the fractions distilling between 235° C. and 305° C., sulphonation test of fraction obtained between 305° C. and 320° C., and determination of tar acids and water.

In the following quotations, all temperatures refer to Centigrade scale.

***Specific gravity of the whole oil.**—The perfectly liquefied oil is poured into a hydrometer cylinder, and, at a temperature of 60°, the specific gravity is read with hydrometer standardized against water at 60°.

***Fractional distillation.**—The Hempel distilling flask of resistance glass is employed. The empty flask is tared, 250 grams of melted, well shaken oil introduced, the platinum-wire plug and the glass beads put in place, and a second weight taken. The thermometer is then inserted in the flask, so that the first emergent reading is 200°. The flask is supported on an asbestos board with a slightly irregular opening of very nearly the largest diameter of the flask. A condensing tube is employed and the fractions are collected in tared flasks. The distillation is run at the rate of 1 drop per second, and fractions collected between the following temperatures: Up to 170°, 170°-205°, 205°-225°, 225°-235°, 235°-245°, 245°-255°, 255°-285°, 285°-295°, 295°-305°, 305°-320°, and if feasible 320°-360°.

The character of the fractions and their weights are recorded and the results plotted as a curve, in which the ordinates are percentages by weight and the abscissae temperatures. When the distillation has reached the 225° point, an asbestos-board box should be placed around the distilling flask, to cover the bulb, but leave the Hempel column exposed. Drafts upon the distilling apparatus must be avoided.

***Index of Refraction.**—The indices of refraction of the different fractions between 235° and 305° are determined at 60° in a refractometer with light compensation. The results are plotted with temperatures as abscissae and indices of refraction as ordinates.

***Specific Gravity.**—The specific gravities of the fractions between 235° and 305° are determined by means of specific-gravity bottles. These bottles are filled at 60° and the weights referred to water at the same temperature. The results are plotted as a curve, in which the ordinates are specific gravities at 60°, and the abscissae temperatures.

***Tar Acids.**—Fifty cubic centimeters of the creosote under analysis are measured at 60° into a small distilling flask by a pipette. The oil is distilled as completely as possible without breaking the distilling bulb, and the distillate is caught in a short-stemmed, 100 cubic centimeter separating funnel. At the end of the distillation 25 cubic centimeters of boiling hot 15 per cent. sodium hydroxide is added to the distillate and the mixture thoroughly shaken. The alkaline extract is then drawn off into a 100 cubic centimeter shaking cylinder and 25 cubic centimeters more of hot sodium hydroxide added. After extracting with this second portion for five minutes, with frequent shaking, the solutions are allowed to separate and the alkaline extract added to the first portion in the cylinder. A third extraction is made with 15 cubic centimeters of alkali. The total alkaline extract is cooled, acidified with sulphuric acid, thoroughly shaken, brought to 60°, and the volume of supernatant oil read off.

***Water.**—After weighing the first two fractions of a fractional distillation they are united in a small separatory funnel, and any water which is present is separated from the oil and its amount accurately determined. If particular accuracy is required in the estimation of the water it may be done by the Marcusson xylol distillation method.

†**Sulphonation Test.**—Ten cubic centimeters of the fraction of creosote to be tested are measured into a Babcock milk bottle. To this is added 40 cubic centimeters of 37 times normal acid, 10 cubic centimeters at a time. The bottle with its contents is shaken for two minutes after each addition of 10 cubic centimeters of acid. After all the acid has been added the bottle is kept at a constant temperature of from 98° to 100° C. for one hour, during which time it is shaken vigorously every 10 minutes. At the end of an hour the bottle is removed, cooled, and filled to the top of the graduation with ordinary sulphuric acid, and then whirled for five minutes in a Babcock separator. The unsulphonated residue is then read off from the graduations. The reading multiplied by 2 gives per cent. by volume directly. (Each graduation equals one two-hundredths of a cubic centimeter.)

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*United States Forest Service Circular 112, "The Analysis and Grading of Creosote," A. L. Dean and Ernest Bateman. Also reproduced in United States Forest Service Circular 206, "Commercial Creosotes," Carlile P. Winslow; and in "Preservation of Structural Timber," H. F. Weiss (McGraw Hill Book Co.)

†United States Forest Service Circular 191, "Modification of the Sulphonation Test for Creosote," E. Bateman. Also reproduced in "Preservation of Structural Timber," H. F. Weiss.

JOHN S. BATES, CHEM.E., PH.D.,

Superintendent, Forest Products Laboratories of Canada, Forestry Branch, Dept. of the Interior, Canada.

Montreal, February 9th, 1916.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Mechanical Technology. By Prof. G. F. Charnock, M.I.C.E., M.I.M.E. Published by Constable & Company, London. 635 pages; 503 illustrations; 6x9 ins.; cloth. Price, $2.00, (Reviewed by A. J. MacDougall, mechanical engineer, Toronto Power Co.)

This book deals principally with the mechanical processes in refining and preparing metals for use in the arts. The chemical and thermochemical changes, however, are not taken up. The book is divided into three parts: the production and properties of materials of construction, the processes depending on fusion, and the processes depending on ductility.

The beginning of the first part is given up to the physical properties of materials—tenacity, elasticity, hardness, toughness, malleability and ductility.

There is an error at the beginning of this chapter. The statement is made on page 4 that water has the greatest specific heat of any known substance. The specific heat of liquid hydrogen is six times and of gaseous hydrogen 3.4 times that of water.

In Chapter 3 there is described the smelting of iron from its ores in blast furnaces. The accessories are given the hot blast stoves, blowing engines, hoisting skips and air gas mains. The properties of pig iron are stated in Chapter 4. Then follow in order, with plans and illustrations, to Chapter 10, the production of wrought iron, classification of steel, the manufacture of steel by the crucible, the Bessemer, the open-hearth, and the electrothermic processes.

The author then takes up in a scientific manner a subject in which there have been great advances in the last few years—alloys and the heat treatment of steel. Credit is given to the late Sir W. C. Roberts Austen for the discovery of physical changes in formation of alloys at various temperatures and the practical heat treatments developed therefrom. Non-ferrous metals and the methods of refining are briefly described in Chapter 13. The metals described are copper, tin, zinc, lead, aluminum, antimony and nickel. Their alloys are given in Chapters 14, 15 and 16. In Chapters 17 and 18 are given the properties and uses of timber and building stones. These chapters describe timbers and building stones in use in Great Britain and therefore lack in value for Canadian conditions.

The author describes in Chapter 19 oils and lubricants, their properties and specifications for various uses. He has neglected to give any statement about the effect of an emulsifying oil and a test of the oil for emulsification.

Leather, rubber and cotton and their use as belting with methods of manufacture are given in Chapter 20.

Part II., comprising Chapters 21 to 30, takes up the moulding of fused metals. Starting with advice as to design and form of patterns to avoid defects in castings, the author proceeds to describe methods of moulding and then gives advice as to the foundry and its equipment, devotes a chapter to steel casting, and finishes this part of the book with defects in castings and machine moulding.

In Part III., Chapter 30 to the end of the book, there are taken up forging and working metals, ductile, plastic, and malleable, at ordinary or high temperatures. After describing the tools and machines required in forge and smithy the author gives in Chapter 30 a classification of operations in forging, and illustrates with examples, and then devotes a chapter to each to describe manufacturing processes, utilizing the ductility of metals. The processes are drop forging, wire drawing, flanging, coining, the rolling mill, and the manufacture of tubes.

All the machines and processes in this book are well described, and the book is valuable to the foundry man and to the smith, to those who have to do with fused or forged metals. But the book might be even more valuable. One would like to know the following about a machine to make any product: the general design of the machine, the process to make the product, the cost of the machine, the power, and the labor required to operate the machine. The cost, power, and labor are neglected in this book and the book lacks in value to that extent.

American Sewerage Practice, Vol. 3—Disposal of Sewage. By Leonard Metcalf and Harrison P. Eddy. Published by McGraw-Hill Book Co., New York City. First edition, 1915. 851 pages; 230 illustrations; 205 tables; 6x9 ins.; cloth. Price, $6.00.

This is the third and final volume of an exhaustive treatment of the subject of sewerage practice. Reviews of the previously published volumes, 1 and 2, relating respectively to the design and construction of sewers, have already appeared in these pages. As in the previous instances, the book under consideration is non-technical in nature, but deals in a comprehensive way with sewage and the changes which it undergoes when subjected to different conditions. The book is undoubtedly intended primarily for engineers connected with the design and operation of sewage disposal plants, but it will be found of great value by civil engineering students, sewerage boards, public health officers and corporation lawyers.

The first six chapters have to do with sewage itself. The progressive steps in sewage treatment are reviewed in Chap. 1. Significance of chemical analyses is considered in Chap. 2; bacteria and their relation to the problem of sewage disposal, Chap. 3; microscopic organisms, Chap. 4; composition of sewage, Chap. 5; theories of sewage disposal and treatment, Chap. 6.

The remaining fourteen chapters deal with subjects of particular interest to designing engineers and operators

of disposal plants, an idea of the scope of this portion of the work being obtained from the chapter headings which are as follows: Sewage Disposal by Dilution; Grit Chambers; Racks, Cages and Screens; Sedimentation, Straining and Aeration; Tanks for Sludge Digestion; Chemical Precipitation; Sludge; Contact Beds; Trickling Filters; Intermittent Sand Filtration; Irrigation and the Agricultural Utilization of Sewage and Sludge; Automatic Apparatus for Dosing; Disinfection of Sewage and Sewage Effluents; and Disposal of Residential and Institutional Sewage.

Although the title confines the scope of the book to sewerage practice on this side of the Atlantic, the authors have provided a great deal of useful and important information from European engineers as well. The book is quite up-to-date in its information. In fact, the authors lay claim to extensive revision and rewriting with this aim in view. The duty of the engineer with respect to sewage and sewerage work is clearly indicated to involve the careful safeguarding of public health. Wise limits of expenditure are advised, this being accomplished most effectually by insisting that each undertaking shall be considered upon its own conditions and that the trained specialist in this branch of engineering shall be the judge of the significance and applicability of experience gained with sewage disposal works elsewhere. The danger of failure resulting from copying plans is pointed out.

In addition to finding the book to be one of great practical value for the subject matter contained therein, the reader will note its completeness in the matter of the selection and arrangement of illustrations. These comprise views of works and of apparatus. The line drawings of plant arrangements, etc., conform, as do the other physical features of the work, with those in the previous volumes. Taken altogether, the engineer will not readily find a more complete compendium of information regarding sewerage practice in America than the three volumes which the above authors have presented.

PUBLICATIONS RECEIVED.

Heat Transmission Through Boiler Tubes.—Technical paper No. 114, U.S. Bureau of Mines; 35 pages.

Ontario Bureau of Mines.—Twenty-fourth annual report, containing 74 pages of information on the Porcupine gold area. Illustrated and containing maps.

Tide Tables for Nelson, Hudson Bay.—An 8-page pamphlet containing tidal data for Hudson Strait and James Bay. Issued by the Tidal and Current Survey, Department of Local Service, Ottawa.

University of Illinois.—Bulletin No. 83 of the engineering experiment station, dealing with magnetic and and other properties of iron-silicon alloys melted in vacuo. Seventy pages, illustrated. Price, 35 cents.

Shot Firing in Coal Mines by Electricity Controlled from Outside.—Technical paper No. 108, issued by the U.S. Bureau of Mines; giving a description of systems in use and suggesting certain improvements; 36 pages.

Mine Ventilation Stoppings.—Bulletin No. 99 U.S. Bureau of Mines. A 30-page illustrated pamphlet very completely describing the types of mine stoppings in use in Illinois, giving costs of erecting and maintaining.

Water Power Branch.—Annual report, Part 8, 1914, of the superintendent of water powers. Three hundred pages, profusely illustrated, and with numerous maps inset. Published by the Department of the Interior, Ottawa.

Copper Deposits in Quebec.—A 290-page illustrated report of the Department of Colonization, Mines and Fisheries, Quebec, prepared by J. A. Bancroft and relating to the copper deposits in the eastern townships of the province.

Motors.—A paper on the single-phase, squirrel-cage motor with large starting-torque and phase compensation. By W. A. Fynn, Consulting Engineer, Wagner Electric Manufacturing Co. Reprinted from the proceedings of the A.I.E.E.

Hazards in Handling Gasoline.—Technical paper prepared by Geo. A. Burrell, of U.S. Department of Mines, outlining relation of properties of gasoline and vapor to inflammability and presenting directions for extinguishing burning fluids.

Gasoline Mine Locomotives.—Bulletin No. 74, U.S. Bureau of Mines. A pamphlet describing the use of gasoline locomotives in mines and methods of diluting the noxious gases, from the standpoint of safety and health. Eighty-three pages, illustrated.

Production of Metals in Canada, 1914.—Advanced chapter of annual report on mineral production of Canada, 1914, issued by Mines Branch, Department of Mines. Relates to 1914 production of copper, gold, lead, nickel, silver, zinc and other metals.

Mexpet Record.—A 16-page illustrated publication describing the oil fields of the company in Mexico and the various uses to which the oil may be put. Also containing a diagram showing the comparative costs of coal and fuel oil. Published by the Mexican Petroleum Corporation, 52 Broadway, New York.

Discovery of Phosphate of Lime in the Rocky Mountains.—A 36-page illustrated Commission of Conservation report, prepared by Frank D. Adams, D.S.C., and W. J. Dick, M.S.C., relating to the geology of these phosphate deposits and illustrated by maps, diagrams and microphotographs.

Petroleum and Its Products.—Bulletin No. 9 of the Kansas City Testing Laboratory. A 20-page pamphlet summarizing the production and uses of petroleum, and containing tables and other useful information for both the refiner and consumer. Issued by the Kansas City Testing Laboratory, 1013 Grand Avenue, Kansas City, Missouri. Price, 25 cents.

CATALOGUES RECEIVED.

Johns-Manville Products.—An 80-page illustrated catalogue describing the varied products of this company. The H. W. Johns-Manville Co., Limited, Toronto.

Bosch & Lomb Optical Instruments.—This is an interesting catalogue of 36 pages, describing various optical applications for the microscopic examination and testing of materials.

The Cement-Gun on the Elephant Butte Dam.—Reprint of article by E. H. Baldwin, assistant chief of construction in U.S. Reclammation Service, Denver, Col., on waterproofing the upstream face of the Elephant Butte Dam, New Mexico, by use of the Cement-Gun. Issued gratuitously by The Cement-Gun Co., Inc., 30 Church Street, New York.

Tiffin Flushers.—This is a twelve-page pamphlet containing illustrated descriptions of the Tiffin flushers, showing their new models of 1,000, 1,200, 1,400 and 1,500 gallons capacity. It gives specifications of the flushers and also some data concerning the sprinkler portion of them and should be of great interest to all those who have to do with the maintenance of roads and pavements.

COAST TO COAST

Winnipeg, Man.—A commission to inquire into drainage questions has been practically promised by the provincial government.

Kingston, Ont.—The Utilities Commission has offered to supply the Street Railway Company with power for ten years at 1.2 cents a kw. hour.

Vancouver, B.C.—It is expected that the new Kettle Valley route over the Hope Mountains will be ready for traffic when the C.P.R. puts the summer schedule into effect on June 1st.

New Westminster, B.C.—The Canadian Northern Railway has recently acquired that section of the old main line of the Great Northern Railway between Fraser River bridge and Port Kells.

Victoria, B.C.—Alluding to certain criticisms of the purchase of the Sooke watershed, Mr. Rust maintains that the city will derive sufficient revenue from the sale of the timber to more than cover the cost.

Toronto, Ont.—At the annual convention of the Ontario Hydro-Electric Railways Association a resolution was passed calling upon the government to restrict exportation of power to the United States.

Galt, Ont.—The new Lake Erie and Northern Electric Railway has commenced operating its line from Galt to Brantford. The Port Dover line is complete except for the overhead construction, which is under way.

Montreal, Que.—The Bell Telephone Company last week successfully opened the Montreal-to-Vancouver telephone line. This line is said to be the longest ear-to-ear circuit in the world, extending for 4,227 miles.

Toronto, Ont.—The Toronto, Barrie and Orillia Railway has applied to the government to be allowed to proceed with the construction of its proposed line. The company has already spent $55,000 on preliminary work.

Calgary, Alta.—City Engineer Craig is in favor of waiting results of the activated sludge experiments before building a new sewage disposal system, which as at present proposed, would cost in the neighborhood of $400,000.

Winnipeg, Man. — According to Superintendent Phillips, over $19,000,000 has been expended in bringing the electric railway system up to its present standard. The number of passengers carried during the last three years averages 50,000,000.

Ottawa, Ont.—Hon. J. D. Hazen estimates that it will cost probably $9,000,000 more to give the St. Lawrence ship channel a width of a thousand feet and a depth at low tide of 35 ft. from Montreal to Quebec. He states that the work will take five years.

Windsor, Ont.—At a meeting of representatives of the five border municipalities here it was decided to form the Essex Utilities Commission to construct and mantain sewer, water, light and power systems at Windsor, Walkerville, Sandwich, Ford and Ojibway.

Berlin, Ont.—At a conference of municipal representatives Sir Adam Beck outlined a scheme for a hydro-radial line from Elmira through Berlin to Galt and thence to Hamilton and St. Catharines, with branch lines running to Guelph, Hespeler and Puslinch Lake.

Limoilou, Que.—Work has started on the construction of the cattle market for the Quebec Abattoir Co. at Limoilou. Work will be done by day labor under the superintendence of Jos. Gosselin, General Contractor. Estimated cost, $35,000. H. Laberge, Architect.

Toronto, Ont.—The Toronto Suburban Railway has asked the York County Council for an extension of franchise to enable the company to connect the present Dundas line with the Georgetown branch at a point near the present terminus of the Dundas line at Lambton.

Calgary, Alta.—Superintendent Breen, of the waterworks department, informed the city commissioners that the matter of water services freezing up was becoming very serious. The cost of thawing out services during this winter will likely be in the neighborhood of $50,000.

Loretteville, Que.—The grading of the St. Charles and Huron River Railway, a branch of the C.N.R., from Loretteville to Stoneham, Province of Quebec, has now been completed. Track will be laid in the spring and the road opened for traffic on June 15th. Jos. Gosselin, General Contractor for grading. C. A. Newton, Resident Engineer.

St. Catharines, Ont.—The Niagara, St. Catharines and Toronto Railway have asked parliament to extend the time allotted for finishing its railway from Fort Erie to Niagara-on-the-Lake; from St. Catharines to Hamilton and Toronto, and from Port Colborne to Fort Erie, but is partly to allow the Niagara, St. Catharines and Toronto Railway time to purchase the Michigan Central line from Fort Erie to Niagara-on-the-Lake.

St. Catharines, Ont.—Although the construction of Sections 1 and 2 on the Welland Ship Canal are behind on the schedule for their completion in the spring of 1917, Chief Engineer Weller states that now construction work is in full swing they are gaining on their schedule and will be ready for opening as intended. He states, however, that it is practically impossible for Section No. 3 to be completed before the spring of 1918, owing to the large amount of concrete to be placed. He recommends that contracts be let for Sections 4 and 8 as soon as possible.

Edmonton, Alta.—During 1915 three hundred and twenty-six miles of new railway were constructed in the province. With the exception of 22 miles built by the C.P.R., the entire mileage was constructed with the aid of government guarantees. The new mileage is credited to the various lines, as follows: Canadian Pacific Railway, 22 miles; Canadian Northern Railway, 59 miles; E., D. & B.C., 97 miles; A. & G. W., 100 miles; Central Canada Railway, 48 miles.

Hamilton, Ont.—There will shortly be a mass meeting of representatives of local municipalities to discuss the hydro radial schemes. There is talk of a branch line from the main radial between Toronto and London with a junction at Port Credit. There is a likelihood of efforts being made to purchase the electric line between Hamilton and Oakville of the Dominion Power and Transmission Co. From Hamilton the radial will proceed to St. Catharines and thence to the Niagara River. It is also planned to build a line from Hamilton to Guelph.

Berlin, Ont.—To a large gathering of municipal representatives Sir Adam Beck recently outlined a proposition whereby existing branches of the G.T.R. and C.P.R. may be used to better advantage and serve as feeders for the main lines in this section of the province. Whereas it will be impossible to construct hydro-radial branch lines parallel to branches already in operation of steam railways, it will be possible to have these branches electrified and to secure running rights over them. Sir Adam instanced the G.T.R. branch from Berlin to Galt and from Berlin to Elmira as well adapted for such use.

Winnipeg, Man.—Concerning the disturbance which has arisen as a result of charges made by Mr. M. T. Cantell against the engineers of the Greater Winnipeg Water District, it is interesting to note that the Manitoba Branch of the Canadian Society of Civil Engineers adopted the following resolution at its recent meeting: "Whereas certain articles have appeared in the Winnipeg public press from time to time criticizing the engineers of the Greater Winnipeg Water District, resolved that it be recorded that the Manitoba Branch of the Canadian Society of Civil Engineers regrets that such criticism has been made, and repudiates any responsibility for the same, and that further, the secretary be instructed to so inform the various newspapers of Winnipeg."

Toronto, Ont.—It was announced by Premier Hearst last week that the provincial government, having before it the general details of the proposed Niagara development of the Hydro-Electric Power Commission, will submit legislation authorizing such development. It is estimated that within the next few years the Commission will require an additional 100,000 h.p. If the expenditure is favorably considered by the government, the Commission will probably proceed with the installation of several large units, probably 50,000 h.p. each, and by the time these are in operation another set of similar capacity will likely be necessary. The engineers of the Commission have in view the ultimate development of 600,000 h.p. at the site proposed. This large development will probably comprise two plants of equal size, each of which will consist of about six units of the extraordinarily large capacity mentioned above.

PERSONAL.

J. H. MEAD has been appointed president of the Spanish River Pulp and Paper Co.

W. G. TRETHEWEY has been appointed resident engineer of West Dome Consolidated.

A. J. CARROLL has been appointed district manager of Eugene F. Phillips Electrical Works, Limited, with office in Montreal.

E. W. DuVAL, until recently superintendent of Saskatoon District, C.P.R., is at present acting general superintendent of Saskatchewan Division.

W. E. CORMAN is at present superintendent for the Excelsior Electric Co., Toronto, on the manufacture of tools and machinery for munitions, having temporarily left the employ of C. H. and P. H. Mitchell.

W. R. SMITH, general manager of the E.D. and B.C. Railway, recently addressed the members of the Board of Trade in Edmonton on "The Development of our Northern Hinterland and What it Means to Edmonton."

Lieut.-Col. WILLIAM H. DAVIS. of the firm of Davis and Lubin, Vancouver, and formerly city engineer of Berlin, Ont., and later of Prince Rupert, B.C., who is in command of the 2nd Pioneer Battalion, which has been in England several months, is seriously ill in the hospital as a result of a fall from his horse. Col. Davis is a member of the Canadian Society of Civil Engineers and a graduate of R.M.C., Kingston.

F. C. GAMBLE, Chief Engineer of Railways for the British Columbia Government, and Past-President of the Canadian Society of Civil Engineers, was entertained by the Edmonton Branch of the Society at a dinner given in his honor in the Macdonald Hotel on the 9th instant. Mr. Gamble has been in the city during the past few days enroute to Victoria, B.C., from Montreal, where he has been attending the Annual Meeting of the Society. About twenty members of the Society resident in Edmonton were present at the dinner.

OBITUARY.

E. B. JONES, at one time city engineer of Chatham, Ont., and an authority on hydraulic and electrical engineering, died recently at Erie, Pa.

CONCRETE PIPE TUNNEL, N.T.R., QUEBEC.

(Continued from page 288.)

In the spring, when the forms were removed, the structure was found to be in first-class condition, and to date no defects whatever have appeared, though the tunnel underwent a rather severe test during the course of the past summer by having work trains run over it at various points.

The concrete specified and made in this work was a 1:2:4 mixture throughout. A small amount of displacers were used, though these were necessarily limited in quantity and of small volume, owing to the small space between the forms. During the construction of that part of the tunnel not reinforced a small amount of salt was also used, though only on exceptionally cold days. The amount of crushed stone, from ¾ in. to 1½ in., used was 0.8 cu. yd. for each cu. yd. of finished concrete. The cement amounted to 1.2 bbls. per cu. yd. of finished concrete. Lumber for forms figured to 60 ft. B.M. to the cu. yd. concrete.

The accompanying illustration, from a photo taken by Mr. H. E. Balfour, assistant engineer in charge of construction for the N.T.R., gives a general view of about 550 feet of the trench with the outside form in place. At the extreme lower end the inner form is also in place and ready for pouring the walls. The photograph was taken from the top of a 200-foot chimney.

The contractor for this work was Joseph Gosselin, of Quebec and Levis, General Contractor for the N.T.R. Shops.

COMING MEETINGS.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Thirteenth Annual Convention to be held at Pittsburgh, Pa., February 28th to March 3rd. E. L. Powers secretary, 150 Nassau Street, New York, N.Y.

CANADIAN MINING INSTITUTE.—Eighteenth annual meeting to be held at the Chateau Laurier, Ottawa, March 1, 2 and 3. Secretary, H. Mortimer-Lamb, Ritz-Carlton Hotel, Montreal.

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION to be held at Sohmer Park, Montreal, March 6, 7, 8, 9 and 10, 1916. General Secretary, Geo. A. McNamee, New Birks Building, Montreal.

At the annual meeting of the Kingston Branch of the Canadian Society of Civil Engineers it was decided to discontinue the meetings of the branch for the present, owing to the fact that so many members are on active service. The chairman of the branch, Major Wilgar, is O.C. 8th Field Co., Can. Engineers, and Mayor Gill, the secretary, O.C. the Queen's Battery in England.

Volume 30. Toronto, March 2, 1916. Contents for this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

USE OF COMPRESSED AIR IN TORONTO SEWER CONSTRUCTION

A DESCRIPTION OF METHODS OF TUNNEL CONSTRUCTION WITH COMPRESSED AIR AND COST OF OPERATING A COMPRESSOR PLANT.

By W. G. CAMERON,

District Engineer, Sewer Section, Department of Works, Toronto.

COMPRESSED air was introduced into sewer tunnel work in Toronto for the purpose of lowering the cost of construction where the ground was of a fluid nature, such as in fine, wet sand which becomes fluid when the overhead pressure is removed. Tunnelling is, of course, possible in most cases without the of ground does not arch, but forms a dead weight on the sheeting. When this fluid ground extends to a depth below the proposed tunnel, and compressed air is not used, the bearing power of the soil must be strengthened, and to do this, it is generally necessary to open-cut from the surface, as the dead weight of the ground above will

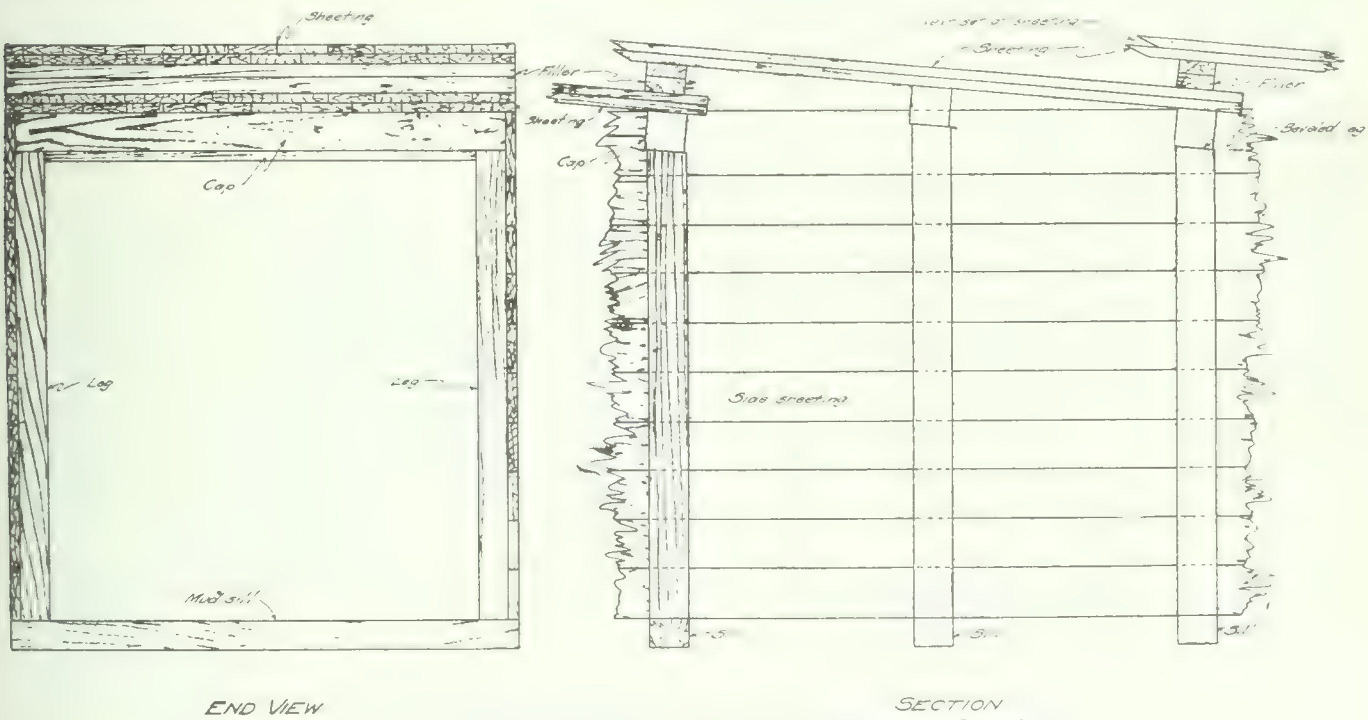


Fig. 1.—Detail of Cap and Leg Method of Supporting Sheeting.

aid of compressed air, but is much more expensive, for not only is a smaller length of tunnel completed each day but a greater quantity of and heavier timbering is required, and the difficulty of placing it is much greater. The sides and roof have to be solidly sheeted in order to prevent the water and sand from escaping into the tunnel in such quantity as to undermine the roadway or pavement or any overhead utilities, such as water mains, gas mains, conduits, etc. Tongue and grooved lumber is sometimes used, or two layers of planks placed one overlapping the joints of the other. This timbering must be heavy enough to withstand the overhead pressure (Fig. 1) as this kind cause the timbering to sink if tunnelling is attempted (Fig. 2). In order to tunnel such ground successfully, then, without undermining overhead utilities, the water which causes the fluid nature of the ground must be forced back. When this water is removed, the ground becomes solid. It is loose enough, however, to be easily mined. To remove the water, compressed air is used, the function of which is to exert a greater pressure in the tunnel than is exerted by the overhead ground, thus forcing the water back beyond the line of the tunnel.

The pressure of air required varies directly as the depth of the proposed work, the quantity of water and the

nature of the overhead ground, whether all sand, a mixture of clay and sand or these two occurring in layers. It depends also on whether the ground contains any old sewers, mains, conduits, etc. Roughly, ½ lb. of air to the foot of depth is assumed, but conditions of the ground vary so much that it is never possible to go

Fig. 2.—Wet Soil Caused Timbering to Sink.

entirely by this figure. Another estimate is ½ lb. of air for each foot of hydrostatic head. Sometimes, where a large sewer is under construction, a greater pressure of air is required to dry the lower part of the tunnel than is required to dry the upper portion, and the overhead ground may not retain this added pressure. Then it is necessary to load this ground down. For this purpose, several feet of earth may be spread on top of it. Cases have been noted where an asphalt pavement has risen over ½ inch when the air pressure was on in a tunnel underneath, and has subsided again when the pressure was taken off. Where there is no pavement, the ground has been seen to rise 1 in. to 2 ins. A person walking over it would find it very much like the first coating of ice on a pond in autumn—rubber ice, as it has been called.

When it is necessary thus to increase the pressure for the lower part of the tunnel, the sand in the upper portion becomes so dry that it falls from the roof like flour. Then, hay or similar material is used, it being stuffed into the cracks of the sheeting to prevent this sand from falling.

The first sewer tunnel built in Toronto with compressed air was that portion of the high level interceptor which runs from King Street and Fraser Avenue, along Fraser Avenue, Liberty Street and Dufferin Street to Springhurst Avenue. It was a 4-ft. 6-in., 2-ring, circular brick sewer, with an average depth of 25 ft. From 6 to 12 lbs. of compressed air were used. The contract was carried out by an American firm, the Gawne Contracting Co. A shaft was sunk and compressors erected on Liberty Street, near Dufferin Street. Work proceeded from each end of the shaft. At the east end, towards King Street, the lower pressure (6 or 7 lbs.) was used, this being sufficient to prepare the ground. The Dufferin Street end required 11 or 12 lbs. pressure to prepare the ground for tunnelling. More than an average quantity of air escaped owing to the close proximity of an old sewer and some other mains. In one case the air escaped through the joints of an old brick sewer on Dufferin Street, one which was built in the days when lime mortar was used instead of cement. It carried the surrounding sand with it into the sewer. The latter settled, spread and then collapsed. The earth over and around it was carried away and about 15 ft. x 30 ft. of pavement undermined. Fortunately, this happened in winter when the electric street railway tracks leading to the Exhibition Grounds were not in use. The rails acted as reinforcement for the pavement and heavy trucks passed over without having any appreciable effect. The cavity was finally discovered by the sewer maintenance men who, noticing a small depression between the tracks, sounded the pavement and so discovered the break.

The next tunnel in which compressed air was used was on Woodville Avenue in the West Toronto system previously mentioned in these pages. This was an 8-ft. circular, 4-ring, brick sewer, the details of the construction of which will be given in a later article. Then followed the main sewer in Moore Park on Sight Hill and Oakmount Boulevard, and another on Danforth Avenue, in East Toronto. A small air pressure was found sufficient on these contracts. Then it was used in West Toronto again and it is there that compressed air has been of greatest value. The ground in this area is all composed of sand and generally carries a great quantity of water at the elevation of the trunk sewers.

The cost of setting up a compressed air plant naturally varies with its size.

Besides the units costing more in a large plant, the cost of the foundations, wiring and all the fixtures will vary. The actual operation of setting up the plant, excavating for and building the locks requires from three to four weeks. The material required is, besides the units, concrete foundations for the compressors, foundation for

Fig. 4.—Steel Cylinder Air Lock.

the motors or engines if they be used, wiring, pipes for air lines, and buildings. If electricity is used, connections are made with the 500-volt system of, if possible, two companies. In Toronto, connections are made with both the Hydro and Toronto Electric Light Co. This is done so

that if the power goes off in one system, power may be immediately taken from the other. If the compressed air is allowed to fail, even for a short time, the water which has been forced from the ground will return and bring sand with it into the tunnel. The result then may be the loss of one or two days in removing the sand from the filled-in heading, erecting new timbering or filling the cavity left by the sand which ran into the heading.

When compressed air is used, air-locks are provided at the shaft to confine the air to the tunnel (Fig. 3). These locks consist of a section of sewer with a bulkhead at each end. The bulkheads each contain a steel door and frame. The doors are fitted with rubber around the edge in order that they may fit tight against the frame when shut. Sometimes a steel cylinder is used for a lock. This only requires a bulkhead at one end (Fig. 4). Generally enough sewer is built in open cut to contain the locks—60 to 70 ft. But sometimes this portion is constructed in tunnel, which is probably cheaper to begin with, but the work is never so tight and it is difficult to maintain the necessary air pressure. When the locks are built in open cut, the ground is all filled in again except the space left for a shaft between the two locks, if two are built. A concrete or brick lining is then erected in this shaft for about 10 ft. above the future sewer or above the possible water line.

Sometimes when high pressure is required, a wedge (Fig. 5) is forced into the solid ground at the end and over the lock to prevent the air from escaping back over the finished work. This wedge consists of a tight thickness of planks the width of the open cut forced into the ground horizontally with jacks, another row on the slant about 4 ft. above the horizontal row, the ends of these meeting the ends of the first. The earth is then removed between these layers of planks and the space rammed full of concrete.

Where the tunnel is for a small sewer, say, 4 ft. in diameter, the volume of air in the tunnel and the area for its possible escape will be comparatively small. Air pumps of 500 cu. ft. capacity will be sufficient. If an air pressure of less than 20 lbs. is required, motors of 40 h.p. are quite sufficient to operate the pumps. Where a larger pressure is required, larger pumps are necessary. In several cases where large sewers were built in Toronto, pumps of 900 to 1,000 cu. ft. capacity were used and these required motors of 50 to 75 h.p. to operate them. The horse-power depends on the load to be carried.

The following is a table of material and costs of a 1,500 cu. ft. capacity plant consisting of two units of 750 cu. ft. capacity each. This table was kindly furnished by Messrs. Jennings and Ross, who are contractors for a trunk sewer on West Toronto Street.

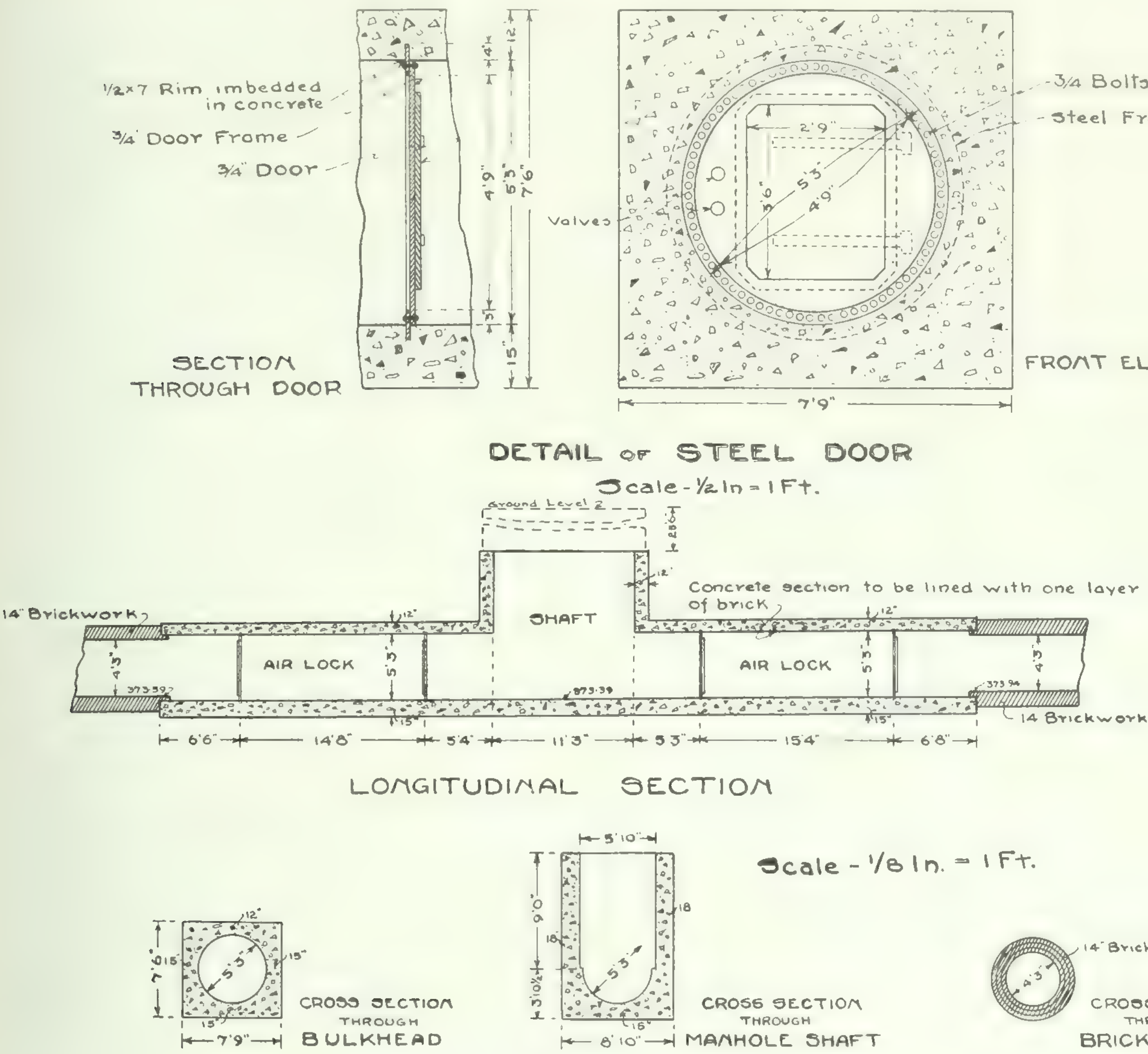


Fig. 3.—Details of Air Locks and Steel Door.

Two Bury (Erie, Pa.) compressed air pumps, 10" x 10", 180 r.p.m., which will give up to 20 lbs. air pressure.

Two Westinghouse motors, 50 h.p., 720 r.p.m.

Two leather belts, 9" and 10", 15' 3" between shafts of pumps and motors.

Two 8' x 8' x 3' 6" concrete beds of about 1 to 12 mixture.

Four 8" x 8" x 16' timbers.

One tank for cooling and muffler, 6' x 16', tested to 135 lbs.

One building, 24' x 30', for housing plant. This is built in sections and may be easily taken apart and set up in any location.

Wiring and 6" piping for air lines. (The switchboard is built in panels and, like the building, may be moved easily at any time. This whole plant may be taken down and moved to a new location in 10 days.)

Air locks, consisting of a bulkhead at each end with a square opening in which is built a steel frame with steel door, the outer door opening into the lock and the inner door into the tunnel. (In this case the gates are 16' apart. The air is pumped directly into the tunnel. Valves are placed through both bulkheads. When a man wishes to go into the tunnel, he walks into the lock and closes the outer door. Then he opens the inner valve which allows the air from the tunnel to escape into the lock, making the pressure in the lock gradually as great as that in the tunnel. He then opens the inner door and proceeds into the tunnel. On coming out, he closes the inner door and opens the outer valve, allowing the air in the lock to escape into the outer atmosphere till the pressure becomes normal.)

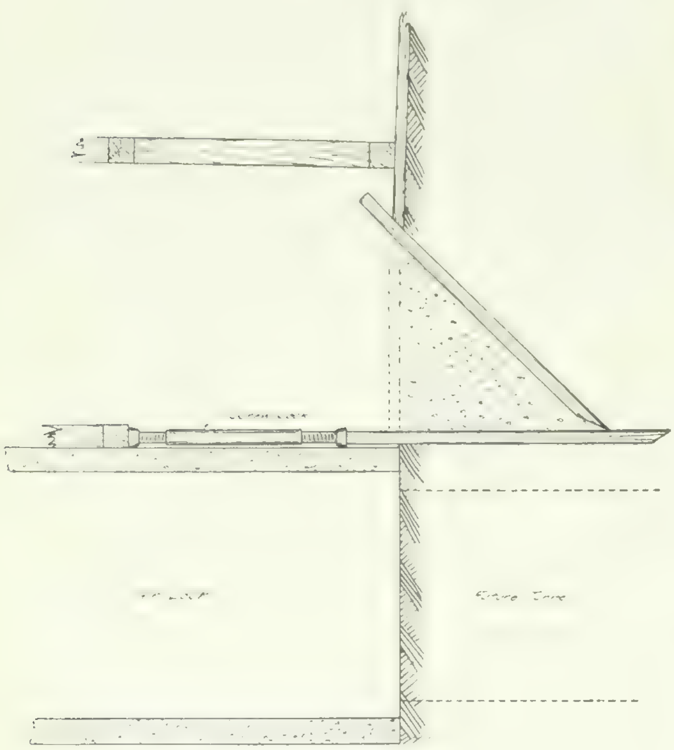


Fig. 5.—Method of Forcing in Wedge to Prevent Escape of Air.

The costs of the plant, installation and operation are as follows:—

Cost of Plant.

2 compressors	$3,000
2 motors	1,300
1 tank	225
2 belts	200
Concrete beds	100
Timbers	10
Building	200

Cost of installing above plant, including wiring and piping, $330.

Gates	$ 395
Valves	100

Cost of installing gates and valves, $112.

Fig. 6.—Compressed Air Plant.

Maintenance.

Power	$360 per month
Oil and waste	20 " "
Wear and tear	20 " "
Operation	350 " "

On an average, 500 ft. of sewer are built per month; therefore, compressed air costs $1.50 for each foot of sewer built. The size of this sewer is 3' 4" x 5', 3-ring, egg-shaped.

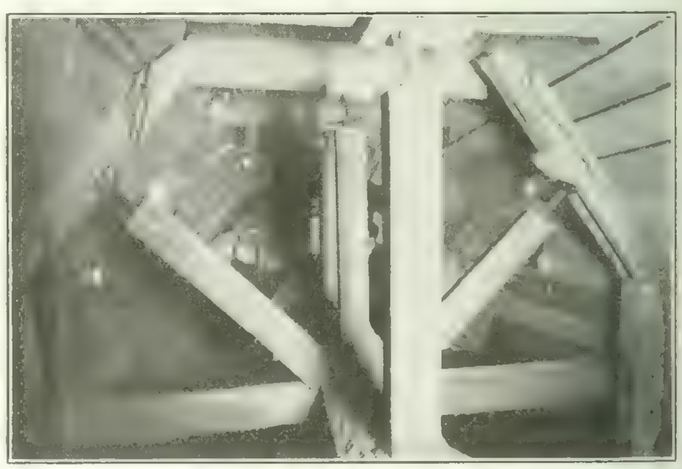


Fig. 7.—Needle-beam Method of Supporting Sheeting.

The following is the cost of a 2,000 cu. ft. capacity plant at present being used by Messrs. Fussell and McReynolds on St. Clair Avenue, to whom we are indebted for this information.

Two Bury air compressors each 1,000 cu. ft. capacity, 16" x 10", 185 r.p.m., will give 30 lbs. pressure.

Two Westinghouse motors, 50 h.p., 720 r.p.m.

Two leather belts, 11″, 2-ply, 15′ 3″ between shafts of motors and pumps.

Two concrete beds for pumps, 1 to 12 mixture, 7′ 9″ x 8′ 10″ x 4′.

Three concrete beds for motors, 1 to 12 mixture, 4′x6′x3′.

Four timbers to keep spacing between motors and pumps. These timbers are at ground level and between the beds; size, 8″ x 8″ x 16′.

One building, 24′ x 30′, in panels to make moving easy.

Wiring and 6″ piping for air line.

Fig. 8.—Cap and Leg Tunnel.

Cost of Plant.

2 compressors	$5,000.00
2 motors	1,300.00
2 belts	295.00
4 concrete beds	145.00
4 timbers	10.50
Building	225.00

The cost of installing the above plant, including piping and wiring, $330.

Gates	$ 400.00
Valves	100.00

Cost of installing gates and valves, including locks, $112.

Maintenance.

Power	$22.00 per day
Oil and waste	.90 " "
Repairs	.60 " "
Labor	11.00 " "

An average of 24 ft. is constructed here per day of 4′x6′, 3-ring, egg-shaped sewer. The cost for compressed air is, therefore, $1.45 per foot, not including interest on investment or depreciation.

When the work has progressed several hundred feet, it is generally advisable to move the locks nearer to the heading. When this is done a smaller volume of air is required and there is a smaller area for possible escape. Sometimes, if air is escaping rapidly, it has been found profitable to discontinue work for a day and pump in grout through the brickwork to seal the space between the brickwork and the sheeting over the arch. This will prevent the air from escaping from the heading back over the finished sewer to the shaft and thence to the surface. This is another reason why the shaft is lined with concrete above the future sewer.

The methods used for supporting the sheeting in compressed air are in many cases the same as those used in ordinary tunnel work with the exception that less and lighter timbering is required. These methods include the needle-beam method, the cap and leg method, the crutch method, the Christmas-tree method and other methods used when only very light sheeting is required.

The Needle-beam Method (Fig. 7).—To use this system the tunnel must be large and dry, or nearly so. (For a detailed description of this method see article in *The Canadian Engineer* for December 9th, 1915, on "The Keele Street Storm Overflow Sewer.")

Cap and Leg Method (Figs. 1 and 8).—This method is used in compressed air when the sewer is small (6 or 7 ft.) and when the sand is fine and has not enough clay mixed with it to give it the necessary consistency. The sand will cave in on the top or sides before sheeting can be placed to prevent it from doing so. The timber cannot be removed from the work and as the sewer increases in size the size of the timber also increases, thus increasing the cost of the work. The sheeting is driven just ahead of the excavation, the cap and legs being placed when the sheeting has been driven ahead of the previous set about 4 ft. The cap in this new set is placed low, and the next sheeting driven over it, the rear end of the sheeting being under the preceding cap, thus giving it always an upward angle. When this set of sheeting is driven ahead its full length, a filler is placed between the sets over the cap, as shown in Fig. 1. The legs are cut on the slant, so that the cap always slants upward and the top sheeting, which is given an upward angle, rests evenly upon it.

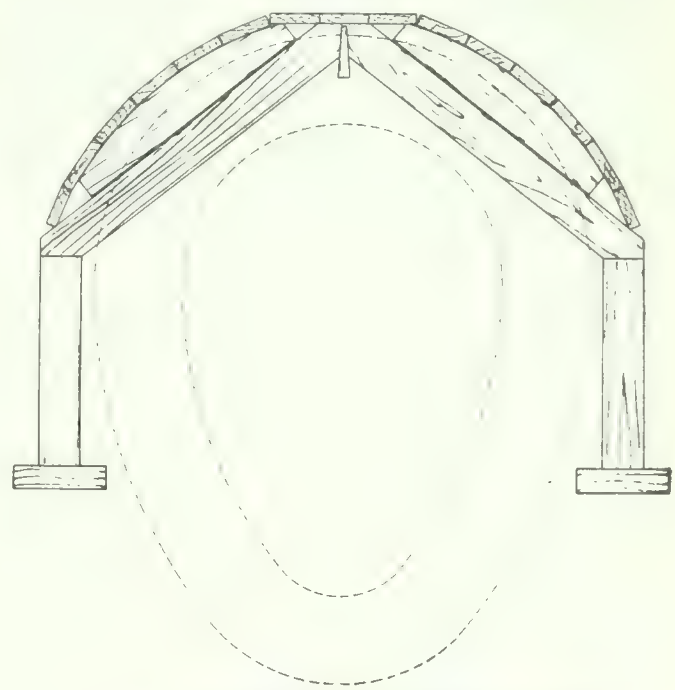


Fig. 9.—Crutch Method of Supporting Sheeting.

The Crutch Method (Figs. 9 and 10).—This method is used when the ground is quite dry and only requires

sheeting in the upper part of the excavation. A narrow drift is driven ahead for 5 ft. or 6 ft. in the centre of the future tunnel, the top being the top of the future tunnel. The crown planks are then placed in position, the front end resting in a deep groove made in the solid ground at the front end of the heading. Should the ground be considered too loose to temporarily support the weight of these planks, a screw-jack on a post, or some similar method, must be used for their temporary support. The drift is then widened on each side enough to allow one plank to be placed at a time. When the sheeting is all placed, a hole is excavated on each side, outside the future masonry, and from the springing line of the future sewer to near the invert. Short planks about 10" x 10" x 2", or possibly bricks, are placed in the bottom of this hole to act as a sill, and a post 6" x 6" placed on the sill. The posts are long enough to reach to the springing line. Timbers 6" x 6" are then placed which form what is called a crutch. That is, they form two chords from the upper ends of the posts to the top and centre of the tunnel. Should these chords be not tight, a wedge is placed between them and forced in until they are tight. A filler the shape of a segment of a circle is placed between the chords and the sheeting, which is in a semi-circle. Should the filler not be used, blocks have to be placed between these crutches and each plank. This section of the tunnel being then complete, the same performance is repeated and another section excavated. This may be easily done, as there is no timber to form an obstruction under the crutches. When the apportioned length of tunnel is complete the bottom of the tunnel (about 2 ft.) is excavated and neatly shaped the shape of the future sewer.

Fig. 10.—Example of Crutch Method.

When the masonry is being built by the bricklayers during the next shift, the lower portion up to the springing line is completed the full length of the excavation. Then the arch is built one drum (2½ ft.) at a time. When the work approaches one of the crutches the brickwork takes the support of the sheeting and the crutch is removed. And so the work proceeds to the last crutch, which is removed by the miners' next shift.

The Christmas-tree Method.—This method differs from the crutch method in that the full length of the shift (8 or 10 ft.) is excavated at once. It is used where clay and wet sand occur in layers, the bottom being dry and the wet sand not being in great enough quantity to require the cap and leg method. A narrow drift is driven ahead in the centre of the tunnel the full length of the shift and two or three crown planks placed in position. A segment is placed against them and a post on sills erected to support them. The drift is then widened as in the crutch method and the sheeting placed one plank at a time. A segment is placed against two or three of these and a spoke radiating from the post is placed to support them. This process is repeated until the sheeting is completed.

RESURFACING OLD MACADAM ROADS.*

ONE of the most important problems confronting road authorities to-day is the question of resurfacing or rehabilitating old stone roads This condition in most cases is the result of neglect. Failure to make repairs or to restore the worn-out portions before a road has deteriorated through to the foundation necessitates the rebuilding of the road and a large expenditure; whereas, through skilled maintenance, the outlay can be reduced materially and spread over a period of years. There are, of course, other reasons for resurfacing old roads, as, for instance, the improper selection of the original material, which is responsible for rapid deterioration, and the constantly increasing and varied traffic, causing abrasive action too severe for the type of road. This latter condition is noticeable particularly in suburban communities and communties where water-bound macadam roads were laid in the early stages of development, and where the population has increased rapidly and where all classes of vehicular traffic have caused the original roadway to deteriorate more rapidly than would have been the case had the development not occurred, thus creating the necessity for repairing and resurfacing in order to make the wearing qualities of the road as good as those in the nearby cities.

The essential points to be considered in the selection of a proper type of surface for an old stone road are the character and amount of traffic, the grades, and, as a rule, that most important factor, the funds available for the work. When the traffic has been determined and the character of surfacing selected a thorough study should be made of the existing foundation and drainage facilities. Many surfaces have been sacrificed for the want of proper attention to the foundation, and too often it is taken for granted that any stone road is a suitable base for most any type of surface. Test-holes should be made at sufficient intervals in the road to determine the depth of the existing foundation, and usually it is found that a considerable portion must be restored before a surface can be applied. Irrespective of the type of surface selected, the preparation of the foundation must be given the same careful attention. Too much stress cannot be laid on the desirability of having proper lines and grades before resurfacing, in order to avoid increasing or perpetuating the difficulties of future improvement of these roads. The question of providing proper underdrainage must be considered, and drains installed where necessary.

Water-Bound Macadam.—The methods used in the preparation of the base for both water-bound and bituminous macadam are the same. If any holes or depressions are found in the base, the road should be dug out and replaced with good-sized clean stone, keyed with a smaller

*From paper before the Pan-American Road Congress, by William D. Uhler, Pennsylvania State Highway Department.

size and rolled with a ten-ton power roller until thoroughly compacted. The roadway should then be cleaned thoroughly and the existing surface broken or loosened with picks, harrows, or, if necessary, rollers equipped with spikes, so that the new material will bind properly with the old surface. Where the new surface is wider than the old base, or where, in improving the lines, it rests partly on the old surface and partly on the old shoulder, it is necessary to provide a new first course or base where an old one does not exist, in order to support properly the top layer or wearing surface.

After the base course has been finished, there should be laid a layer of properly graded, approved stone, passing a two and one-half inch mesh screen, and being retained on a one-inch mesh screen, this stone being known as "1½-inch." The stone should be spread upon the base course with shovels from piles along the side of the road or from a dumping-board, but in no case should the stone be dumped upon the first course surface. This layer should be rolled with a roller weighing not less than ten tons until it is compacted to a firm and even surface. The total thickness of the surface course should be not less than three or four inches after rolling. When a surface course of a depth of three inches is specified, it should be laid in one layer and a four-inch course should be laid in two layers of two inches each.

Should difficulty be experienced, while rolling, in getting the stone to compact thoroughly, sprinkling with water or spreading lightly with screenings will prove beneficial.

After the surface course of stone has been thoroughly rolled, screenings, varying in size from dust to ¾-inch, should be spread with shovels from piles along the side of the road or from dumping-boards, but, again, in no case should the screenings be dumped directly upon the surface of the stone. These screenings should then be thoroughly rolled with a ten-ton steam roller, additional dry screenings applied, and the rolling continued without the use of water until the interstices of the stones are filled. The road should then be sprinkled with water, rolled, additional screenings spread, and the sprinkling and rolling continued until the surface is well bonded and set. The rolling, in all cases, should begin at the sides and work toward the centre of the roadway, thoroughly covering the area with the rear wheels of the roller, and should be continued until the surface is hard and smooth and shows no perceptible tracks from vehicles passing over it.

To protect a water-bound macadam road from the ravages of automobile traffic it should be given a bituminous surface treatment of either approved tar or asphalt. Prior to applying this bituminous material, the surface of the road should be cleaned thoroughly by sweeping with machine and hand-brooms. After all the caked dust has been scraped off and the stone exposed uniformly over the surface, the bituminous material should be applied.

Bituminous Macadam.—In resurfacing with bituminous macadam, the base course should be prepared as for water-bound macadam, after which stone passing a two and one-half inch screen and retained on a one-inch screen should be spread upon the base course with shovels from piles along the side of the road or from a dumping-board to a depth of three inches after rolling. After the broken stone has been laid and placed true to line and grade and cross-section, it should be rolled with a roller weighing not less than ten tons until the stone has been thoroughly compacted and ceases to creep in front of the roller. When the rolling has been finished there should be spread evenly over the surface a quantity of approved bituminous binder, not less than 1½ nor more than 1¾ gallons to each square yard of surface area. The binder should be heated to the proper temperature for the material used. After the bituminous binder has been applied, there should be spread a layer of ¾-inch dry, crushed, approved stone, free from dust, and in such quantity as will just cover the surface and fill the surface voids. Rolling should be continued until the surface is thoroughly bonded; the surface then should be swept clean of all loose stone and an application of bituminous binder, of approximately one-half gallon to the square yard of surface area, applied evenly. This binder, in turn, should be covered immediately with a thin layer of dry stone chips, free from dust and rolled lightly. The quantity of chips should be just sufficient to absorb the excess of bituminous material remaining on the surface and to prevent the existence on the surface of an excess of binder.

Bituminous concrete and sheet asphalt pavements should be laid on a concrete base, instead of on the old existing macadam foundation, which, heretofore, has been the generally accepted practice for country roads. In view of the increased amount and change in character of traffic, even though slightly more expensive, it is advisable to provide for either a four-inch or a five-inch concrete base on top of the broken stone or telford base, due to the tendency of macadam to shift or to consolidate further under traffic and possible sub-grade trouble, all of which tend to bring about a wavy or uneven condition of the surface.

In the resurfacing of water-bound macadam it is frequently the case that the engineer in charge of the work allows too small a stone to be used, which, it is true, will require decidedly less rolling, but will not stand the motor traffic of to-day.

Another fault quite often found is the spreading of screenings before the one and one-half inch stone is thoroughly locked, and very frequently using too large quantities of screenings, thereby causing a heavy crust to form on the road surface.

The success of the bituminous treatment of water-bound macadam roads depends entirely upon the cleanliness of the road before the application of the material. Many failures are due to the lack of proper care in this most important detail. In cleaning the surface of the road the sweeping should be windrowed along the edges of the wearing surface, in order to prevent the running off of the bituminous material, which later should be swept back on the road. Special attention should also be given to the applying of the chips, just sufficient chips being used to prevent the traffic from picking up the bituminous material.

In bituminous macadam or penetration work no bituminous binder should be applied unless the stone surface is thoroughly dry, and the temperature of the air is 65 degrees or higher, and special attention paid to the heating and applying of the binder.

One of the important features in connection with obtaining the best results in bituminous concrete construction is the use in the wearing surface of good, hard, durable stone, free from dirt and decomposed material, as decomposed stone in the mixture will naturally develop weak spots in the pavement and ultimately result in failure.

The penetration of the asphaltic cement used in the mixture should be governed by the character of the traffic requirements.

As before stated, the success of all bituminous concrete and bituminous pavements is very largely dependent upon the rolling, and the best results can be obtained only by using a light roller for the initial compression and a heavier roller for the final compression, with an equal amount of transverse and longitudinal rolling.

In the laying of sheet asphalt or bituminous concrete, where brick gutters are used and adjacent to block runners along car tracks, it is good practice to lay the finished surface of the pavement from one-eighth to one-quarter of an inch higher than the brick gutters or runners. It is difficult in the rolling to secure final compression next to these blocks, and traffic will further compress that portion of the pavement, naturally causing the development of low spots, which hold water and result in deterioration.

Special attention should be paid also to the heating of the various aggregates entering into the pavement, and also of the combined mix, as many failures are caused by over-heating. No over-heated material should be used under any circumstances, as failure is bound to result.

WORKING AIR OUT OF PIPE LINE TESTED IN LONG SECTIONS.

By using a hand force pump to raise the test pressure to the required 250 lb. where necessary, loosening the high joints to permit the escape of air, and providing heavy end bracing and clamps to take the thrust of ½-mile sections under test pressure, an 8-in. steel pipe line about 8½ miles long was quite recently tested satisfactorily, according to R. C. Hardman in *Engineering Record*.

The specifications provided for testing the line to a pressure of 250 lb. per square inch before backfilling the trench. Part of the line received normally more than this pressure when the discharge end of the line was closed, but, as no valve was provided at the reservoir, static pressure could not be obtained in operation. Where the pressure exceeded the required amount the pipe was simply capped and the line examined. Where the pressure was less than 250 lb. it was raised to that figure.

The tests were made about every half mile immediately upon the completion of that amount of pipe-laying. A small hand-operated boiler testing pump was used for the purpose, although some doubt was had as to whether it would be feasible for increasing the pressure in such a long length of line—about 2½ miles being the longest section tested. In preparing for the test a cast-iron cap fitted to the end of the pipe and tapped to receive the discharge of the test pump was securely fastened to the last section of pipe. This was accomplished by means of a steel bar over the casting, through which bolts were passed, the bolts in turn being fastened at their opposite ends to a steel clamp which bolted around the pipe. Water-tightness was secured by means of a rubber gasket between casting and pipe end. As the pressure tending to force the casting off the pipe and to disjoint the line was about 12,500 lb., a system of timber bracing was employed. At the first test, which was at a creek crossing, the pipe was braced against the opposite bank so effectively that the line was buckled completely out of the trench, the last joint being broken.

As the line followed the contour of the ground there were many high points in which air collected. The procedure in making the tests was to cap and brace the lower end, loosen all high joints to allow escape of all air and close the valve in line at the intake. Water was then hauled in barrels for the operation of the pump. The time consumed in reaching the desired pressure was not uniform throughout the series, varying from two to six or seven hours for four laborers working in ½-hour shifts of two men each. The variation in time was due to the amount of additional pressure necessary and to the care with which the accumulated air had been released. At times when it was thought that the air had been carefully attended to no headway would be made by the pump, a more careful inspection always revealing the fact that some air still remained in the line. In fact, to increase pressure in this way it is absolutely essential that all air be removed.

FOURTEENTH ANNUAL MEETING OF THE ONTARIO GOOD ROADS ASSOCIATION.

Greater interest seemed to be taken in the meetings of the Ontario Good Roads Association this year than heretofore, nearly every municipality affiliated with the association was represented at the convention. S. L. Squire, of Waterford, was again elected president of the association.

The practical side of road building claimed more attention than usual this year, and the subject of financing good roads was also given its share of the program. Among the technical papers presented to the convention was a paper by Lucius Allen, county engineer of Hastings, on "When is Crushed Stone Profitable?" In it he described the various uses of stone, its adaptability to certain locations and conditions, and methods of good construction, dealing at some length on rolling the surface. Mr. Allen stated that a well-drained stone road with a surface impervious to water was equal to any type of modern construction. "When is Concrete Paving Possible?" was the subject dealt with by H. S. Van Scoyoc, chief engineer of the Toronto and Hamilton highway. Mr. Van Scoyoc stated that concrete roads are most profitable when they give better value per dollar of expenditure than any other type of satisfactory surfacing material. While improved roads create values that cannot be measured in dollars and cents, a commercial standard is the one most readily set up. More care should be taken in the preliminary work as the initial cost of concrete highways justifies more careful grading and drainage work than when a less permanent type of construction is used. The speaker stated that as concrete roads are a comparatively new type their lasting qualities were not definitely known. At any rate it is safe to assume that after, say, 20 years of service the concrete road can be used for sub-base purposes.

E. A. James, engineer for York County Highways Commission, gave an address on "When is Bituminous or Other Paving Profitable?"

Numerous resolutions were drawn up and will be presented to the government. Most of them dealt with the cost of road building material.

The following officers were elected: S. L. Squire, Waterford, president; honorary presidents, N. Vermilyea, Belleville, and J. A. Sanderson, Oxford Station; 1st vice-president, C. R. Wheelock, Orangeville; 2nd vice-president, J. J. Parsons, Haldimand; secretary-treasurer, Geo. S. Henry, M.P.P.; directors, W. H. Pugsley, York; Major Kennedy, Peel; L. E. Allen, Hastings; F. A. Senecal, Prescott; David Clow, Leeds, and K. W. McKay, St. Thomas.

THE ADMINISTRATION OF A COUNTY ROAD SYSTEM.*

By G. Cameron Parker, B.A.Sc.

THE Council is the main executive body administering the affairs of the county; from its members are appointed various committees, each dealing especially with its branch of the work. The committee having charge of the improvement of highways is usually known as the Roads and Bridges Committee, and to this body the County Road Superintendent is directly responsible. The council usually lays down a programme covering the season's work, but any modification of this is authorized by the Roads and Bridges Committee.

It is essential, therefore, that the greatest co-operation exist between the superintendent and the committee, and the smaller the committee, the greater will be the despatch with which the work is conducted. It is impossible to call a large committee together on short notice, and, as the value of a committee depends to a great extent on its ability to meet and consider matters without delay, a small road committee is strongly advised as against the procedure in some counties of placing the whole council on the committee.

The success attained by a county road organization depends almost entirely on the knowledge and executive ability of the superintendent. He must, therefore, not only be a practical road builder, familiar with the work in all its phases, but he must possess business acumen in order to direct the general work or the organization.

The experience necessary to develop these qualities is not gained in a year, and herein lies the great disadvantage of changing the road superintendent from year to year, as is the custom in some counties. It takes a year or more to acquire a thorough knowledge of a county road system and to become familiar with local conditions, and this experience is gained at the expense of the county. Every time a new man assumes the office of superintendent this expense is repeated, at a loss to the municipality. We do not find private corporations changing their executive heads every twelve months. Once a suitable man has been placed in a position they make every endeavor to retain him, realizing that he is becoming more valuable every year. Why, then, should not municipalities practise the same economies that are laid down as basic priciples in other corporatons, and, securing a capable superintendent, make him feel that the position is his as long as he conducts the affairs of the road organization in a satisfactory manner. No man will take the same interest in, or put the same energy into his work, if he feels that his term expires with the present council that he would if he knew that the success or failure of "Good Roads" in his county depended on him, and that he was not only to plan for this year, but for those to follow. He will then consider road-building as his profession, and the best results are obtained when a man is working along one line, with a clearly defined object in view.

When appointed, the superintendent should make it a point to become familiar with the history of the county roads. Where the system has been in existence for only a few years this is not difficult. If the roads are not covered with snow he should cover every mile, paying special attention to present and future traffic requirements and the condition of the districts through which the roads run. The work done by the townships prior to the introduction of the system and by the counties since that time should be located and work necessary for repairs and maintenance made note of. As the appointment to the office of superintendent usually takes place early in the year, there follow several months during which this and a great deal of other valuable preparatory work may be done.

Special attention should be paid to drainage at this time. When the water is lying on the ground and in the side ditches it is much easier to determine what is necessary to provide drainage than when it has dried up.

This is the time also to have the machinery repaired and put in first-class condition. Delays on the work cost money, and they should be avoided as much as possible by a thorough overhauling of the equipment, making any repairs that are necessary at the time, or which may avoid breakdowns later in the season. While all machinery should be attended to, special care should be taken with the roller and quarrying equipment. Once work has commenced these are operated for ten hours a day, six days of the week, and there are too many delays owing to bad weather without adding to them by the neglect of the equipment.

Provision can also be made at this time for the housing of the machinery during the following winter. If sheds have not been erected they can be built before the men are needed on the road. Every day that is taken in moving an outfit from one job to another expense is going on and no results are obtained, apart from delays in the work. In counties owning several outfits the sheds should be built at the centres of the districts served. A framework of stout studding, covered with corrugated iron, will afford ample protection, but care should be taken to provide for wind stresses and snow loads on the roof.

If new equipment is to be purchased the superintendent should make himself familiar with all the types and makes on the market, and after giving the matter serious consideration and gathering the experience of others, he should decide on the type of machines desired and make an effort to have the council procure them, The council, on the other hand, should realize that the superintendent is in a better position to know the machinery he wants to work with and should be governed by his recommendations,

The spring is the "open season" for the grading machine. At no time during the year can it be used to such advantage as when the ground is soft and workable. A dollar spent in grading at this time will secure better results than twice the amount spent when the ground is hard and has to be broken into lumps and again compacted by traffic, and the work is not so discouraging to men and horses nor so wearing on the machine.

The grading gangs should be the first part of the organization to receive attention, and care should be taken to see that the man who is to operate the grader understands the work thoroughly. He may have used the machine and yet be unfamiliar with the minor details. He should be watched closely from the start and advised from time to time where his work can be improved. Failing to get one with experience, a man should be hired who lives nearby. He should not be overburdened with instructions at first, but taught the general principles and his faults corrected. In this way he will feel that he is improving from day to day and take a greater interest in the work.

*Read before the Conference on Road Construction, Ontario Department of Highways.

All the earth roads on the system should be gone over with the grader, leaving only the fine grading to be done where construction is to take place later on.

The draining of the roads should accompany the grading, and for the same reasons. The side ditches should be cut or cleaned out and brought to grade; the outlets should be opened, and cross and side culverts inspected and cleaned where necessary.

The roller should be put in operation on the roads already built as soon as the subgrade is sufficiently solid to support the load. The construction work done during the previous fall should be gone over and the tendency to rut and ravel reduced by several trips of the roller. In many cases where ruts have formed or pot-holes started a few shovelfuls of 1-inch stone will put the road in condition without the use of the roller. When the surface is moist and the spring rains are on the traffic will quickly compact the small stone. When not used on repair work the roller should be sent over the roads as much as possible. As said before, macadam sometimes will break up on the surface during the second year, owing, perhaps, to not receiving sufficient rolling in the hurry and rush of the construction season. This can be made up for by getting the roller at work early and keeping it on the road till frost sets in.

As soon as time permits attention should be paid to the materials that are to be used during the season. The life and service of the roads depend on the quality of the materials used in construction, consequently a wise choice is necessary. If local material is to be used the deposits should be inspected, provision made for removing the water and the most economical method of working them decided upon. In this connection I might say that I have noticed a tendency in some counties to use the inferior material near the surface rather than go to the trouble and expense of going deeper and securing better stone or gravel.

Limestone deposits in particular usually yield tougher and harder stone at a depth of from six feet down than they do above that level, and in most cases the first two or three feet consist of shaly layers that, while easy to take out, make very poor macadam.

Roads built of materials from quarries or gravel pits that have been worked should be inspected and the traffic which they carry determined as closely as possible. The service to be expected from the material and the desirability of using it can then be decided.

Where there is doubt as to the desirability of using domestic materials rather than importing them, if application is made to the Department a survey of the deposits in the county will be made, tests conducted, and a report furnished to the superintendent, with advice as to the best material to use.

In counties where stone has to be imported or purchased from commercial quarries the superintendent should have specifications drawn up for him and call for tenders based on these specifications. The specifications should lay down the quality of stone required, as shown by laboratory tests, and the contractor should understand this, and know that his material was liable to be sampled at any time. Only in this way can the superintendent be sure of getting what he is paying for, and in the event of a dispute with the party furnishing the stone the specifications showing the requirements in black and white will form a basis of adjustment where it is necessary.

The specifications for stone as now used usually state that "It shall be a hard, blue limestone, free from dirt, etc.", and that "It shall be subject to the approval of the superintendent." These are right as far as they go, but often out of consideration for the contractor or in a desire to get the work finished the superintendent is inclined to be lenient in his decison. With proper specifications he is not put to the necessity of straining his conscience and the contractor is not so apt to furnish inferior material, trusting to his ability as a salesman to persuade the superintendent to accept it.

As in other matters pertaining to their organizations, superintendents will, upon making application, receive such assistance as they desire from the Department in the preparation of specifications and the selection of materials. In the event of the adoption of specifications not prepared by the Department they should be submitted for approval before proceeding with the awarding of contracts.

The actual road construction should commence as soon as it is practicable to haul materials. The construction gangs should be organized, and on the care with which this is done the smoothness of operation of the outfits during the whole season depends. For the position of foreman preference should be given to a local man, provided he is capable. Needless to say, a man with previous experience in road-building, or failing this, a man who can handle men well should be the first choice. He should have the selection and hiring of the men for the gang with the exception of the roller engineer. The man for this job should be hired by the superintendent only after consideration of his energy, ability and character. A roller engineer who has periodical "wet" spells in the neighboring town is no man for the job no matter what his qualifications are. Throughout the whole construction force the men should be kept at the same work as long as it lasts. The "breaking in" of men to new jobs involves a loss in money as well as in the quality of work. From the beginning till the end of the season each man should know his particular work and should be kept at it.

Where roads are built by contract the superintendent should have an inspector on each job, who should be furnished with a copy of the specifications and be instructed to promptly report any unauthorized departure from them on the part of the contractor. No matter how carefully specifications are drawn up there are always unforeseen conditions arising where they may be modified. Sometimes this is to the advantage of the contractor and sometimes it will be to the advantage of the county. There should, therefore, be a feeling of cooperation between the superintendent and contractor and a certain amount of give-and-take. Good and satisfactory work can never result when the two parties to a contract are at loggerheads.

The clerical work in connection with a county road system presents a big problem to the superintendent, and where there are a number of outfits working in widely separated parts of the county most, if not all, of his time is spent on the road. He should have someone in the office to look after the accounts when they come in and distribute the items under their proper headings. In this connection it might be said that attention should be paid to see that the maintenance charges do not creep into the construction accounts, and vice versa.

With little additional labor a unit cost system can be developed which will show the cost of the various individual items during the time covered by the pay-

sheet. By closely watching these costs the superintendent can keep a check on the different gangs and alter methods and institute economies wherever necessary.

The contractor considers a unit cost system his most valuable asset. He watches this from day to day in order that he may stop losses on any of the small operations before they reach large proportions and keeps an eye on his equipment and sees that repairs are made promptly with the least delay.

There is no reason why the same principles should not govern the work in a municipal organization. The dollar is of the same value to the county as to the contractor, and it is the duty of the superintendent to see that he makes it do as much. To many the term "Efficiency" represents an ideal condition striven for by many but reached by few. In its plain meaning, where the expenditure of money is involved, it is the ratio between the value of results obtained from a certain piece of work and the amount expended on it.

WATER USERS' COMMUNITY PLAN OF CO-OPERATION IN BRITISH COLUMBIA.

THE following statements respecting recent water legislation in British Columbia are from an address by William Young, Provincial Comptroller of Water Rights, given before the recent convention at Bassano, Alberta, of the Western Canada Irrigation Association. The reader's attention is called to *The Canadian Engineer* for December 3rd, 1914, in which an article by Mr. Young appears, dealing with the changes that had been made from time to time up to that year in the water laws of the province and to the changes that were necessary to permit of effective administration. The following remarks refer to how the Water Users' Community legislation was adopted. We necessarily omit the various sections* of the Water Act given in Mr. Young's paper, but would refer to it those in other provinces desirous of community legislation of a similar nature:—

In speaking of the Water Users' Community legislation of British Columbia, reference must be made to the irrigation Corporation. The latter was in a measure the direct outcome of a resolution of the Western Canada Irrigation Convention, held at Kelowna, B.C., in 1912. The Irrigation Corporation Bill was accordingly prepared for the legislature session of 1913, but did not become law because it was pointed out that there were features which should be reconsidered; and it stood over until the session of 1914. This not only gave ample time to redraft it, but an irrigation season in which to administer under such amendments as had been made to the Water Act. The administration of water during that season (1913) revealed many defects, chief of these being the necessity for provisions that would make possible the enforcement of beneficial use, and also for provisions that would permit of co-operation in various other ways. These defects were remedied in the session of 1914, and the Province has now its particular laws on irrigation and the water bailiff, and on co-operation in the Irrigation Corporation, the Land and Water Company, the Mutual Water Company and the Water Users' Community.

*See Section 160 of Part VII. and Section 125 of Part VI. of the Water Act, British Columbia Statutes, 1914, for clause relating to the Water Users' Community, Irrigation and the Water Bailiff, respectively.

The Irrigation Corporation is familiar to many. The Land and Water Company provision replaces an imperfect law in respect of irrigation companies. Under this law it is no longer possible for the land promoters to incorporate first as a land company and then as a water company. They must now in their procedure outline a plan for the organization of a company for the benefit of the prospective purchasers of the subdivided lands, to be known as the Settlers' Association, and must further set out the proposed form and terms of the water clauses to be incorporated in all contracts for the sale of their lands. The Mutual Water Company provides that owners of land who are water licensees may organize a company with particular powers which will permit of the construction of joint works for conveying purposes. The Water Users' Community simply provides for a partnership of licensees in the construction, maintenance or operation of works. This is the subject of the address.

The Water Users' Community is of basic importance for the reason that where, as yet, in places the settlements comprise but a few farms, it permits of inexpensive but safe organization that later on may develop into one of the larger organizations mentioned. The law has supplied a long-felt need that was promptly taken advantage of in several valleys.

The feature that is new about the Water Users' Community is the fact that by following the instructions as set out in the water Act the members can avoid being individually responsible for all the acts of the Community. It was at any time possible for several licensees to co-operate under the "Partnership Act" as a "limited partnership." In this form of partnership, however, only the liability of the "special partners" is limited, the "general partners" being jointly liable for all debts and obligations of the firm, and severally liable for certain acts. Now, even though it was possible by means of this act and a series of agreements to co-operate with limited liability, it meant a procedure, not only expensive and complicated, but most uncertain. No attempts were, therefore, made to organize until co-partnership was fitted into the Water Act under the title of the "Water Users' Community."

Whenever a Water Users' Community is contemplated, attention is drawn to the sections in the Water Act in respect of irrigation and the Water Bailiff, as ultimate success largely, if not wholly, depends thereon. "In fact," states Mr. Young, "if we have had any measure of success in the administration of irrigation, it is quite as much due to these sections as anything."

To the Water Users' Community the sections on irrigation are tbe basis of any system of rotation agreed upon. In perhaps the fewest words possible the very essentials of successful irrigation are brought home to each member. In respect of the section on the water bailiff, it might be said that the powers conferred on him are too great. It, however, depends entirely on the man who should be selected as having qualifications that particularly fit him for the work.

How this Form of Co-operation Works Out.—A prospective community, if left to itself, does not readily get together in agreement; different views are presented. The holder of the first record probably has been dragged through several of the courts in the defence of his water right and for a time has faced ruin. Being successful in his defence and having enjoyed some years of peace, he does not propose to be a party to anything that will jeopardize his rights. The holders of one of the later rights takes the stand that he is not always sure of a

share of the water, and, since it is hard enough for him to get along, he wants to be certain that in becoming a member of the Water Users' Community he is not taking upon himself a liability that may mean the loss of everything he has. The result usually is a request that the Comptroller attend one of their meetings, when an effort is made to explain the several points provided in the Act and then answer any questions. The first record holder is told that membership in the community will not affect the status of his rights. The holder of the last record has explained to him the limited liability provision. Administration is also carefully explained, reference being made to the laws on irrigation and the duties and powers of the water bailiff, attention being directed to the fact that the water bailiff is under the direct supervision of the district water engineer. This is an important feature, for, should the partners fail to agree on a system of rotation in use of water, the engineer prepares the order and sets the dates.

Another point with the prospective community is whether or not it is necessary to employ a lawyer. The majority is usually not in favor of having the lawyer because of the expense, and to meet their wishes the Department prepared a form which comprises the Articles of Partnership, which have been made as simple as possible that those interested may understand them.

The first district to take advantage of these provisions was Heffley Creek Valley. It did not take the men of this Valley long to come to a decision; in fact, they were ready to go ahead before the law became effective in the Railway Belt. Here it was realized that only by means of organization and co-operation would contention cease. The Heffley Creek Water Users' Community has been, and is, a success. It comprises about twenty farms, which, together, have about 1,000 acres under irrigation. As a result of all parties doing their share an excellent reservoir has been developed. The provisions in respect of irrigation and the water bailiff have demonstrated that order and reasonable system works to the advantage of everyone. Several incidents that have happened show that the problems of conservation of water, alienation of water to another watershed, and the granting of new rights which are of vital interest to the Valley are more fully appreciated, and the secretary of the community is making it his business to see that these problems are properly considered by keeping in touch with the departmental officers. In the old days these same problems were the business of everyone, yet of no one in particular, with the result that no united action was taken.

In another district a community is in process of organization. In this case it was necessary that an agreement be entered into with two of the prior record-holders for the use of their ditch. For some reason or other the prospective members at one time reasoned that the agreement should be first entered into, then the community formed. Finally, they were advised to see a lawyer, who confirmed the advice of the department. The difficulty in this instance is the agreement. The record-holders did not fully appreciate their status and the powers of administration under the Act. Under these powers the administrators take the stand that it is not in the public interest to permit construction of parallel ditches, even on Crown land, where one ditch will serve the same purpose. These record-holders have been given to understand that they must fall in line, and that any system of rotation in use of water ordered will be enforced. As the same time they are assured that this will work no hardship, since any order of rotation gives first rights their due consideration.

Co-operation under the Water Users' Community is proving of some assistance to the administration. To illustrate this: a short time ago a landowner in the Heffley Creek Valley wrote, enquiring if he could secure a water right on Heffley Creek. He was advised to confer with the Heffley Creek Water Users' Community. Their answer being favorable, he wrote accordingly, which the Water Rights Branch confirmed by writing the secretary of the community. The result was that in due course a right was applied for. Had this man applied in the days prior to the organization of the community there is not the slightest doubt but that there would have been objections from all who already held rights. The applicant and the objectors would have employed lawyers. It would also have meant considerable investigation by the department before any decision could have been arrived at. All the expense, litigation and delay that these proceedings would mean was put to one side by the community itself in one brief letter to the Comptroller.

There is just this to say in conclusion, that if the Water Users' Community plan of co-operation is proving a benefit to those who have taken advantage of it, it is likewise proving of assistance to the water administration of British Columbia in satisfactorily disposing in some cases of what have been contentious districts.

SOME MINOR PROBLEMS IN A HIGHWAY BRIDGE DESIGN.*

By L. M. Hastings.

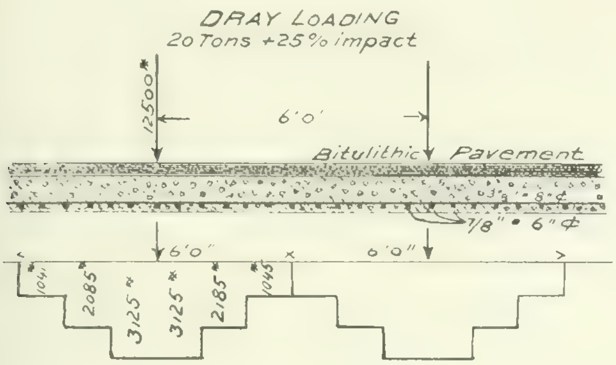
THE highway bridge at Walden Street, Cambridge, over the main line of the Fitchburg Division of the Boston and Maine Railroad, has a width of 42 ft. between sidewalk railings, and a length between abutment bearings of 61 ft. This bridge, as constructed in 1892, had two main steel plate girders with steel floor beams carrying the floor joists of hard pine. The floor was of 3-in. hard pine covered with 2-in. spruce. The sidewalks were carried on steel brackets.

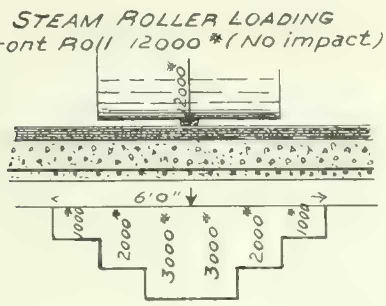
The railroad here has four tracks and is built on an ascending grade going west. The clearance between the rails and bottom chords of the bridge was only about 15 ft. 6 in. This brought the tops of the engine smokestacks very close to the lower members of the bridge, with consequent rapid loss of metal by the mechanical effect of the blast, besides the chemical action of the smoke and gases upon all exposed surfaces. Various means were tried to protect the more exposed portions of the steel members from these effects. A heavy coating of asphaltic paint, cement mortar held with expanded metal and heavy sheet lead, were tried with only indifferent success. Finally, the portions of the members exposed to the direct action of the blast from engines were covered with ⅞-in. plain oak sheathing, held firmly in place with iron clamps, the sheathing first being thickly covered on its upper side with a paste composed of red lead and Portland cement. This was found to work very well, the oak sheathing showing surprising resistance to the destructive action of the blast. Some pieces of oak taken from the bridge after ten or twelve

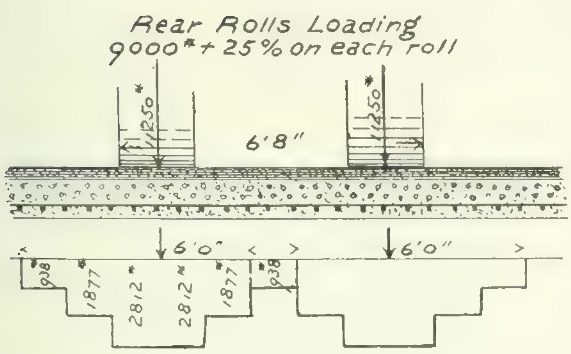
*Read before the Boston Society of Civil Engineers.

years' exposure showed a loss of not over 1/4 in. in thickness.

The portions of the metal not so protected were, of course, exposed to the continued action of the smoke and gases, and continual repairs were necessary to keep







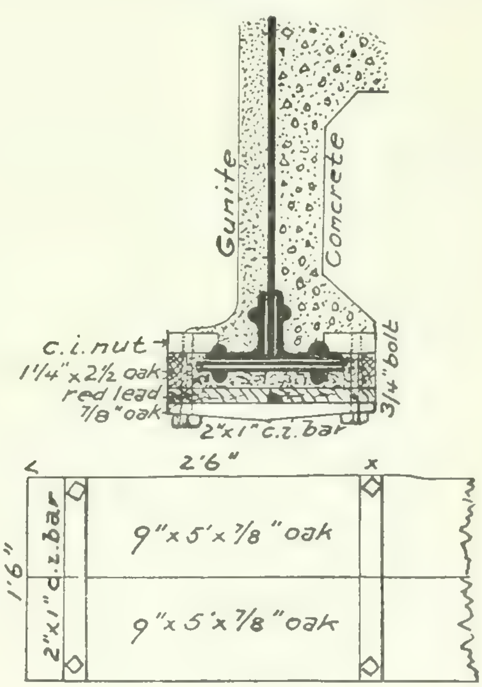
the bridge even fairly safe. The first cost of the bridge superstructure in 1892 was $3,063.80. The total cost of maintenance and repairs on the bridge from its erection to 1913 was $3,815.85. In 1913 the bridge had become so weakened that it was declared to be unsafe for travel, and in 1914 it was decided to build a new one in its place.

The new bridge is carried on three main plate girders, 63 ft. long and 42 ft. between centres of the two outer ones. The entire floor for roadways and sidewalks is of reinforced concrete slabs carried by steel beams so arranged that no slab shall be of more than eight feet span.

In designing the details of this bridge, two rather interesting problems were encountered. The first related to the distribution of the assumed concentrated live loads upon the floor slabs, from which the proper amount of steel reinforcement could be determined. The slab itself was assumed to be about 9 in. thick and to be covered with a bitulithic pavement about 4 in. thick. The usual live loading for that class of bridge was taken, namely, a four-wheeled dray weighing, loaded, 20 tons, with wheels 6 ft. apart and axles 12 ft. apart, or a steam roller weighing 15 tons with rolls 11 ft. apart, and with 20 per cent. additional for impact and vibration in computing stresses. No data as to the distribution of such loads on the floor slabs under these conditions being available, an empirical assumption had to be made. The conditions of loading producing maximum stress would be as shown on the accompanying diagrams. While it was clear that the slab had some degree of flexibility and must show deflection under loading, it was assumed that the concrete, bonded laterally by the cross reinforcing rods, would distribute the stresses over a considerable distance. After trying various assumptions for distributing the stresses, the one shown on the stress diagrams was finally adopted.

On the first, it was assumed that the load of 12,500 lbs. was carried equally by the reinforcement on either side of its point of application, and that the influence of one-half of this load, or 6,250 lbs., would be extended for a distance of three feet from its point of application in a diminishing amount, and that one-half of that amount, or 3,125 lbs., would be carried by reinforcement in the first foot, one-third, or 2,085 lbs., in the second foot, and one-sixth, or 1,045 lbs., in the third foot, making the entire load to be carried by the reinforcement in a strip of floor six feet wide.

In the second case, the front roll of the steam roller was considered. In this the entire load of 12,000 lbs. was assumed as applied at one point but without the 25 per cent. addition for impact, as it was thought that if impact was produced by the roll, as in passing over a stone, it could be only when the roll was returned to the surface, and the load was then automatically distributed by the roll itself. The flexible hanging of the front roll would also assist this distribution. The assumptions for



distribution were as before. The greatest load in this case would be 3,000 lbs. per foot.

In the third case, the rear rolls of the roller were considered, and the assumptions as to load distribution were the same as in the first case. The maximum loading in this case would be 2,812 lbs. per foot.

The loading used in determining the amount of reinforcement required was 3,125 lbs, per foot applied in the centre of the span.

Before the bridge was completed, the contractors for the paving rolled it with a fifteen-ton roller, passing it repeatedly back and forth over the bridge. The deflection was so small as to be unnoticeable.

The second problem related to the best method of covering the exposed sides of the two outer girders. They are seven feet high, and to cover them with cast concrete was difficult unless the covering was made rather thick. If the covering was cast thick enough to be practicable, the dead load was greatly increased. It was, therefore, proposed to use the "Cement Gun" and apply the covering only about two inches thick. When the bids were received, however, it was found that the price demanded for the use of this method was excessive, due to the unfavorable position of the surfaces to be treated over the constantly passing trains beneath. It was suggested that the "gunite" be applied to the girders at the shop after they were fabricated, and that then they might be shipped to the site on the cars. The contractors for the bridge finally adopted and carried out this plan with entire success. The two girders were given a covering of "gunite" in the yard of the shops and were transported on cars to the site and the bridge erected without starting a crack, so far as could be discovered. The "gunite" forms a dense, firm covering, which seems to adhere with great tenacity to even the smooth surfaces of steel plate.

Where the railroad tracks pass under any of the main or secondary members of the bridge, the bottom flanges are protected with the oak covering already described, and shown on the accompanying diagram. Twenty-four of these oak coverings, each five feet long, were used on the new bridge.

NOVA SCOTIA STEEL AND COAL COMPANY.

The chief impression gathered from an examination of the financial statement for 1915 of the Nova Scotia Steel and Coal Company is that the management has taken advantage of the favorable conditions in the steel industry materially to improve the company's position. Current liabilities, for example, were reduced from $2,622,723 to $1,866,378, a substantial decrease of $756,345. Liquid assets were increased by $3,000,000, much of the gain being accounted for by an increase of $2,238,284 in current assets, which now stand at $5,015,890. An increase of $633,874 was made also in the special reserve account, which now stands at $1,773,423. In bills payable a heavy reduction was made. A year ago, they totalled $1,785,000, and at the end of last year only $490,000. The accounts payable, amounting to $1,108,938, are double those of 1914, a natural development in view of the fact that the company probably has the largest payroll in its history.

The net profits for the year, after making the usual provisions, were $2,094,169. With the balance of $57,466, from the previous year, there was a total of $2,151,636 for distribution. The sum of $36,309 was paid to the trustees for the bondholders on account of sinking fund and used by them in retiring 5 per cent. bonds of the company. After making that transfer and after paying bond and debenture stock interest, and also one year's accumulated preference dividends to December 31st, 1915, there still remained at the credit of profit and loss account the sum of $1,510,609. This is a balance greater by $1,453,143 than that of a year ago. The statement is obviously the best in the company's history. It indicates that Colonel Cantley, the president, his directorate and staff have not allowed much to escape their notice during the past year.

The Nova Scotia Steel and Coal Company holds 51 per cent. of the stock of the Eastern Car Company. At the end of the fiscal year of the latter company it had an undivided balance of $250,455. Its profits since the end of its fiscal year have amounted to $230,000. This gives to the present time an undivided surplus of about $500,000. The company has recently closed an additional contract for 3,000 cars, to be completed in about five months' time.

ECONOMIC AND STRATEGIC ASPECTS OF ENLARGEMENT OF WELLAND CANAL AND OF CONSTRUCTION OF GEORGIAN BAY SHIP CANAL.*

By R. W. Leonard, M.Can.Soc.C.E.

THIS is a most important subject for debate by the Canadian Society of Civil Engineers, because it involves vitally the probability of continued existence of our international boundary, as well as the question of the economic expenditure of vast sums of money, and because it is a question that should be solved by civil engineers.

Internationally, the question involves the use of constricted water-ways at Sault Ste Marie, St. Clair River, Detroit River, Welland Canal and St. Lawrence River by both peoples, some of which waterways are on one side of the boundary and some on the other, and the effect of such a condition in case of friction unhappily arising between Canada and the United States.

Commercially, the economics of the projects can be compared with transportation by rail and with one another. The expenditure involved and where it is spent, and the effect of the expenditure upon the country as a whole, are most important.

Civil engineers alone can make the surveys and determine the physical possibilities of construction, the cost of construction, and the relative engineering advantages or disadvantages in the construction, maintenance and operation, as compared with railway transportation on the one hand, and the one canal project with the other on the other hand.

This question is apparently of such wide scope, and involves technical detailed knowledge of so great variety that the writer submits it affords ground for much valuable discussion, which it is to be hoped will be elicited by this admittedly imperfect and faulty paper, contributed with diffidence but in good faith by the writer as his view.

The present canal system of commercial importance consists of:—

Sault Ste. Marie Locks:—

$$\left.\begin{array}{l}\text{1—on Canadian side } 900' \times 60' \times 19' \text{ draft}\\ \text{1—on U.S. side } 600' \times 100' \times 14' \text{ draft}\\ \text{1—on U.S. side } 800' \times 100' \times 19' \text{ draft}\end{array}\right\}\text{ being operated.}$$

1—on U.S. side 1,250′ x 80′ x 24½′ draft, opened October 21, 1914.

1—on U.S. side expected to be ready in 2 or 3 years.

Channels in U.S. territory below locks in Sault.

Channels in Canada and U.S. in St. Clair River.

Channels in Canada and U.S. in Detroit River.

Welland Canal, including 24 locks, 270′ x 45′ x 14′ draft.

St. Lawrence canal system, 26 locks, 270′ x 45′ x 14′ draft.

After the War of 1812 the British Government—recognizing the necessity of having a line of communication for military purposes away from the boundary—canalized the Ottawa River from Montreal to Ottawa, and the Rideau and Cataraqui Rivers from Ottawa to Kingston for barges drawing five feet of water at a cost of $3,911,700, which system they subsequently gave to Canada free of cost.

The Department of Railways and Canals has since nearly completed the Trent canal system from Trenton on

*Paper prepared in 1914, and presented in 1916 to the Canadian Society of Civil Engineers.

Lake Ontario to Georgian Bay, for barges drawing about five feet of water at a cost to date (1914) of $13,611,035, exclusive of interest.

These last two systems—however interesting to the summer tourist as canoe and yachting routes—are not of great economic or strategic importance under modern conditions.

The cost, maintenance, operation and repairs for the year 1913 being $309,822.65, and the tonnage passing through (mainly pleasure boats, cord wood, lumber and sand) amounted to 227,023 tons.

About 1904 the Dominion Government (Public Works Department) started a survey of the Ottawa-French River route for the purpose of arriving at the cost of a 22-ft. ship canal. The result is embodied in a very voluminous report, dated 1908, including estimates as follows:—

Total length of canal, 440 miles, 22 ft. deep, including:- Free navigation, 346 miles; improved channels, 66 miles; excavated canal, 28 miles. Cost, $100,000,000.

The system is estimated to be capable of developing 1,000,000 h.p. on the direct canal route, and this estimate might probably be doubled by figuring the power developed in regulating the tributary streams.

It is significant that about the same time the Department of Railways and Canals commenced to make surveys to determine the possibility of enlarging the Welland Canal from the present 14-ft. draft to 30-ft. draft. These surveys were completed in 1913 and the parliamentary estimate for that year included $2,000,000 for the enlargement of the Welland Canal and $500,000 for canalizing the French River from Georgian Bay to Lake Nipissing.

The total estimate of the cost of enlarging the Welland Canal (26 miles) is reported to be $50,000,000, probably two-thirds of which is expended in the United States for fuel and machinery, and in various foreign countries in the form of wages sent home by laborers.

The lift of 325 ft. is overcome by 7 locks of 46.5 ft. lift, 800 ft. long x 80 ft. wide x 30 ft. draft.

The St. Lawrence canals enlargement has not been surveyed and no information is therefore available to indicate whether corresponding enlargement to suit that at the Welland Canal is physically possible at *any* cost of construction, and the people of Canada have not been informed of any treaty with the United States sanctioning such deepening of international waters with the probable construction of international dams, etc.

During 1913-14 contracts were let for the construction of about 10 miles of the Welland Ship Canal, including all the locks, at a cost of probably $35,000,000, and the work of excavation is possibly half done.

Internationally considered, this question is of supreme national importance, as involving such questions as national defence and the very possibility of holding Canada for the Empire.

In this connection, it must be borne in mind that New York State is enlarging the Erie Canal from Troy to Oswego and to Buffalo, from 6 or 7 ft. draft to 12 ft. with a lock length of 311 ft., and width of 45 ft., to accommodate barges of 1,500 tons capacity,* and these canals will open Lakes Ontario and Erie to formidable United States war vessels, giving them absolute control of these lakes at all times, unless Canada be supplied with similar transport facilities apart from the boundary waters of the St. Lawrence River from Kingston to Prescott.

The enlargement of the Welland Canal will also carry a great preponderance of large United States steel freighters into Lake Ontario, thus giving to that country an undisputed control of that lake.

Canada has enjoyed a century of peace with her powerful southern neighbor, and it is the wish of all good citizens to enjoy another one, even avoiding in the coming century such incidents as the "Trent Affair," the Fenian Raids, Venezuela messages and the Panama Canal question, and serious boundary disputes, fishery disputes, international water power questions, etc., to say nothing of United States Senate reports, 1889-1890 (Testimony of Joseph Nimmo, Jr.), etc. Such questions having arisen in the past, however, they will naturally arise in the future, and the peaceful settlement of them depends largely upon the temper and temptations at the time. So long as an international boundary is to be retained, so long should the policy of Canada be to preserve peace while safeguarding her honor and interests.

It is not apparent to the public that this canal problem (probably Canada's most expensive commercial project under construction) has been considered by the Canadian people from the national point of view, though pamphlets have been published *ad nauseam* by Boards of Trade of various municipalities treating the subject in a spirit of parochial politics, each exaggerating the advantages of one route and the disadvantages of the other, the very apparent incentive in each case being the expenditure of public money on construction in the immediate vicinity of the municipalities interested.

If the question be approached from a purely economic point of view, it is probable that freight (and grain from the prairies to the Atlantic seaboard in Canada is the most important commodity at present) can most cheaply be handled by rail from Winnipeg to Fort William and Port Arthur, by ship to Georgian Bay, and by rail over a direct line with easy gradients to Montreal, than by any canal at present built or proposed. On this route the C.P.R. has a double track from the West to Fort William; the G.T.P. and the C.N.R. have each a single track between the same points. There is a large fleet of United States steamers engaged in the coal, grain and ore trade on the lakes, and the Canadian fleet is growing rapidly. The C.P.R. has a line with easy gradients from Port McNicoll, on Georgian Bay, where it has built large grain elevators, to connect with its Toronto-Montreal line, with a view to carrying grain in competition with the canals, and they probably have estimates of comparative cost warranting the expenditure, even under the unequal conditions that the traffic by the railway must pay interest, depreciation and upkeep, while the government assumes these enormous sums in the case of the waterways, making the canals free to all ships alike, Canadian and foreign.

The people are educated to demand water transportation "to regulate rail freights," and to what extent a larger canal than the present 14-ft. Welland-St. Lawrence system will result in a reduction of rates is a question that can be figured in many different ways with varying results. Figures have been prepared by competent authorities showing that the maximum saving in freight on wheat from Fort William to Montreal by the enlargement of the Welland Canal will be 3/8c. per bushel, which will amount to $187,500 per year on 50,000,000 bushels—at a cost in interest on $50,000,000 of, say, $2,000,000 per year plus depreciation, upkeep and operation.

Return cargoes of coal are obtained in Lake Erie ports. Probably few will contend that 14 ft. draft ships are not economical for package freight from Lake Ontario or St. Lawrence points.

It will be of interest in this connection to have a report on the feasibility and cost from an engineering point

*Report of State Engineer and Surveyor, 1913.

of view of lengthening the existing locks on Welland and St. Lawrence canals 100 ft., and the economic results of such lengthening if it be practicable.

To analyze and compare the respective advantages and disadvantages of these two routes.

Assuming that the government enlarges the Welland Canal and proposes to canalize the French River to North Bay only:

The estimate for the enlargement of the Welland is generally stated to be $50,000,000; which amount at 4% interest, together with amortization, upkeep and supervision of the two existing canals and the proposed canal, may be estimated at another $1,000,000, or a total of $3,000,000 per year, which sum is probably under the mark unless all past experience in cost of government contracts be reversed.

Assuming the distance from Port McNicoll to Montreal to be 400 miles, and a paying freight rate to be four-tenths cents per ton-mile, or $1.60 per ton, or 5c. a bushel, then $3,000,000 per year would pay the rail freight from Georgian Bay to Montreal on 60,000,000 bushels, which is much greater than the amount of grain and flour shipped in the past from Montreal in any one year, and 50% greater than the greatest Canadian tonnage through the Welland Canal bound down in one year.

This enlargement of the Welland Canal will not materially increase the water power development, as that is regulated by international treaty and works out so that, though Canada owns two-thirds of the water flowing over Niagara Falls, she gets the use of only one-third of the power development therefrom, the United States getting two-thirds.

It is manifest that the only saving effected by enlarging the Welland will be that effected by the difference in freight rates between 2,000-ton ships from Port Colborne to Montreal *vs.* 8,000-ton ships from Port Colborne to Prescott, plus 2,000-ton ships from Prescott to Montreal, estimated above at ⅜c. per bushel on wheat.

Oswego is about 150 miles nearer (by Erie Canal) to Troy than is Buffalo, and, as the enlarged Welland Canal will be, by treaty, free to United States ships, their largest lake ships will deliver grain cargoes to 1,500-ton United States barges at Oswego, in the New York State Barge Canal for New York instead of into 200 or 300-ton barges at Buffalo as at present, and thus compete with large Canadian ships discharging into 2,000-ton barges at Prescott or Kingston for Montreal.

In the past the little Erie Canal boats taking grain from Buffalo to New York have been very keen competitors against the St. Lawrence route. What will be the result of the new conditions when in operation? It would appear that the expenditure on the proposed Welland Canal enlargement when completed will be quite as much to the advantage of the United States as to Canada, and during construction probably much more than half the cost goes to the United States for coal and machinery.

The canalization of the French River to North Bay to a depth of 22 ft., a distance of 82½ miles, is estimated to cost $14,275,000, and would develop 35,000 h.p.*

It could bring coal and coarse freight to North Bay for railway distribution, and return pulp-wood and probably ores from that district, and partially develop a lot of power for which there is probably no immediate market in sight, but the value of which will doubtless be very great in a few years, if we judge from the phenomenal increase in the use and value of hydro-electric power during the past 20 years. Probably this construction is warranted only in anticipation of the completion of the entire canal to Montreal.

*Report of Government Engineers, 1908.

Assuming that the appropriations in the estimates for the Welland and French River works are preliminary to the extension of each system through to Montreal:

The Welland-St. Lawrence system (unless an entirely new route inland to the north of the St. Lawrence can be found) passes through international waters from Kingston to Cornwall, and probably nothing can be done toward enlarging this portion without international agreement, including a natural demand by the United States for a share of the power development, (loosely estimated at 2,000,000 h.p. by some writers in the press).

Would the United States, having the free use of the enlarged Welland to carry their big ships to Oswego (the end of their Erie Canal) consent to the enlarging of the St. Lawrence system to divert the trade from Troy and New York to Montreal? What share of the expense would they bear? What share of the power developed would they demand?

Sufficient information is not available to indicate the nature or cost of such an enlargement of the St. Lawrence canals, to a depth of 22 ft.

In the case of the Ottawa-French River system, careful surveys and estimates have been made by the Public Works Department. The total length of the canal is 440 miles, of which 346 miles is free navigation, 66 miles in improved channels and 28 miles in excavated canal.* The cost is estimated at $100,000,000.*

The system is estimated to be capable of developing 1,000,000 h.p. on the direct route* and 3,000,000 h.p., including the tributaries† which probably within 20 years will (if carefully conserved and utilized by the nation) be worth from $20 to $100 per year per horse-power utilized over the cost of production from coal, depending upon the purpose for which it is used.

In the absence of authentic estimates and reports on the St. Lawrence route, it is impossible to compare the two routes as to practicability, cost, time of transit and economy of operation. It is not known whether the St. Lawrence enlargement is at all possible, due to international questions. If it be possible, then the two systems can be compared in regard to length and total height of locking only.

From Lake Superior to Montreal the Ottawa route is 661 miles long, and the total lockage up and down is 780 feet.

The Welland-St. Lawrence route is 943 miles long, and the total lockage is 578 feet.

Both routes pass through United States waters in the St. Mary River. The St. Lawrence route passes through contracted international waters at St. Clair River, Detroit River and St. Lawrence River.

The deepened Welland-St. Lawrence Canal would be found to have probably three times the length of actual excavated canal and about the same length of restricted river navigation, as compared with the Ottawa route.

Much has been written about fogs, rock-excavated channels and sharp curves on the Ottawa route. Any Canadian knows that the St. Lawrence probably suffers quite as much as the Ottawa from fogs. About half of the existing Welland Canal is in rock excavation and the new canal will not have less. It is not known how much of such channels the proposed St. Lawrence enlargement will include. The Ottawa route has sharp curves, so has

*Report of Government Engineers, 1908.
†Estimate of Government Engineers, 1908.

the Thames below London, and it is not known what curves will be required on the proposed St. Lawrence enlargement. There are, however, sharp curves in swift currents in St. Mary River at Neebish and other points.

Without surveys, the distances through restricted waters cannot be compared and therefore neither the time necessary to pass through, nor the dangers of navigation.

The St. Lawrence route is known to be longer and will demand greater fuel consumption per ton of freight, and probably more time in transit.

The weeks per year when they will be open for navigation will probably not greatly differ, although the St. Lawrence system would doubtless have a slight advantage in this respect.

If, as shown above, the annual expense of enlarging the Welland Canal alone would pay the freight on double the quantity of wheat and flour at present carried per year from Lake Huron to Montreal, it is unnecessary to prove that (commercially speaking) neither scheme can be defended as a canal solely. Without further information they cannot be compared physically, nor is the possibility of the St. Lawrence enlargement even sure.

Conclusion.—Pending the result of discussion the writer cannot avoid the following conclusions:—

(*a*) Neither canal system can be made, as a canal, a commercial success.

(*b*) On account of the geographical position and abundance of power capable of being developed along the Ottawa-French River system, that canal and power development (if undertaken by the government) can probably be made a commercial success in a few years and will be a very valuable asset in case of international disputes, giving Canada a chance for defence on the Upper Lakes that she can never enjoy without it. This canal might be considered by the Dominion Government on the same basis as colonization railways which have been freely encouraged all over Canada.

(*c*) The possibility of the enlargement of the St. Lawrence system is as yet undetermined, as it requires the co-operation of the United States.

(*d*) The cost and value of the power development thereon is unknown as no international agreement, surveys or estimates have been prepared.

(*e*) The enlargement of the Welland Canal without a corresponding enlargement of the Welland-St. Lawrence system will at least benefit United States quite as much as Canadian interests, and it is questionable if it will not divert trade from Montreal to New York.

(*f*) It will give the United States control of Lake Ontario in case of international trouble, and be an important factor contributing to the probable loss of the wealthiest and most populous part of Canada.

The Dominion Government has recently appointed a commission to report on the proposed Ottawa Ship Canal, which doubtless will add much to the present knowledge of the commercial feasibility of this project, and it is to be hoped of an alternative project of a 14-ft. barge canal.

It is to be hoped that it will also give some similar information regarding the enlargement of the Welland Canal and the proposed extension of the enlargement to Montreal that will guide the government in deciding on the wisdom of such vast expenditures of public money before the projects are actually undertaken.

It is to be regretted that a similar commission had not been appointed before the government committed the country to the expenditure of several hundred millions, on the simultaneous construction of two additional transcontinental railways, and numerous other expensive projects.

NOTE—The following figures are added for reference. They have been taken from Canal Statistics, Department of Railways and Canals, 1911, and Report of Government Engineers on Georgian Bay Ship Canal, 1908. It is very difficult to get definite and accurate information regarding water transportation costs, which heretofore have not been obtained by the government, and some of these figures are subject to correction; especially those relating to freight rates, insurance charges and interest, which are liable to change from year to year.

Distances.—Fort William to Montreal (via Georgian Bay Canal), 934 miles; Fort William to Montreal (via Welland Canal), 1,216 miles; Fort William to New York (via Erie Canal), 1,358 miles.

Proposed Georgian Bay Canal (length) 440 miles—French River village to North Bay, 82½ miles; North Bay to Montreal harbor, 357½ miles. Free navigation, 346 miles; improved channel, 66 miles; canal excavation, 28 miles.

Canal Depths.—Proposed Georgian Bay Canal, 22 ft.; Welland-St. Lawrence Canals, 14 ft.; proposed Welland Canal, 24 ft.; Sault Ste. Marie Canal (Canada), 20.2 ft.; Sault Ste. Marie Canal (U.S.), 16 and 20.5 ft.; Erie Canal, 7 ft.; New York State Barge Canal, 12 ft.

NOTE—Excavation in St. Mary River, below the locks, has materially reduced depths over lower sills below figures in the above table.

Lockage.—Proposed Georgian Bay Canal, 27 locks, 758 ft. up and down; existing Welland Canal, 26 locks, 326 ft.; proposed Welland Canal, 7 locks, 326 ft.; St. Lawrence Canals, 22 locks, 207.5 ft.; Erie Canal, 72 locks, 660 ft.

Rates.—Water rate on grain, Fort William to Montreal, 4½c. bushel. Water rate, Fort William to Buffalo, 3½c.; rail rate, Buffalo to New York, 5½c.—9c. bushel. All water rate, Fort William to New York, 5.3c. bushel.

NOTE—Water rate Fort William to Buffalo is at times as low as 1½c. per bushel.

Although distance and rates are in favor of Montreal, diversion to American ports is due to the following reasons: Availability of ocean tonnage at New York; lower ocean rates between New York and foreign ports; lower insurance rates from New York.

Insurance.—Montreal, 65c. to $1.10 per $100; New York, 12½c. to 15c. per $100.

Cost of existing Canadian canals, Fort William to Montreal, $80,000,000; interest at 3½%, $2,800,000; maintenance and operation, $1,400,000; total, $4,200,000.

Water freight rate per ton-mile, Fort William to Montreal, .163c.; interest and maintenance, .135c.; total, .298c.

Government contribution, .135c. per ton-mile.

Welland Canal traffic, 1912, 2,537,629 tons, of which 51% was Canadian and 49% American.

On the 51% of Canadian traffic the government contribution would amount to .265c. per ton-mile, as compared with a freight rate of .163c. per ton-mile.

Rail freight, Fort William to Montreal, on grain 0.421c. per ton-mile; water freight, Fort William to Montreal, including interest and maintenance, 0.428c. per ton-mile.

It will be seen that the all-water rate from Fort William to Montreal, including interest and maintenance

of canals, would exceed the all-rail rate by .007c. per ton-mile, based on the amount of Canadian traffic passing through the Welland Canal, but in case tolls were charged to meet these interest and maintenance charges, the United States traffic would also have to contribute towards this revenue, and the ton-mile charge for the all-water route would be reduced to .295c. per ton-mile.

Government contribution does not include cost and maintenance of harbors, lighthouses, buoys, etc.

THE CARE AND OPERATION OF QUARRYING AND CRUSHING EQUIPMENT.*

By R. M. Smith, B.Sc.

THE writer, in presenting this paper, wishes to deal with the care of modern portable quarrying and crushing outfits and the manufacture of road metal as applied to county road systems. The first operation that confronts the superintendent in moving the crushing outfit to a new location or opening a new quarry is the stripping. If this is of considerable depth it demands consideration. Earth is generally removed at prices varying from 25 to 30 cents per cubic yard. Very often, however, the work is exposed and no stripping is necessary, and in this case the stone on the surface has been subject to varying conditions of the weather, and as a result should be culled from road metal.

Crushers are either of jaw or gyratory type; those used in Ontario are practically all of the jaw type and particularly in portable outfits. Of first importance is placing of crusher; all other equipment depending upon its location. Providing it is intended to work from surface downward some arrangement must be made for draining of quarry. If dump carts are being used, an incline plane is necessary that material may be conveniently moved to crusher. However, if quarry is on side hill and can be opened from a face, the drainage problem is of little importance. Material is moved from quarry face to crusher along bed of quarry with little or no tractive resistance. Operating a quarry on side hill from a face is probably less expensive and more efficient than any other method. Work down hill, not up, should be the motto in quarrying operations. Several quarries somewhat of a permanent nature operating in the province have the crusher below elevation of quarry face; narrow-gauge tracks have been laid and stone is moved by gravity from quarry face to crusher in small cars holding from one to two cubic yards. The tracks are placed so that crusher can be fed from both sides at once or alternately, and as a result jaws are always full. The crusher should be placed as near quarry face as possible, but at sufficient distance to prevent damage to equipment from flying debris. It is well to emphasize setting of crusher on timbers, making it absolutely rigid. A crusher allowed to operate while standing on its wheels is being hurried to the scrap pile, and not only does not work efficiently, but, due to axle bearings wearing, increases the traction power necessary to haul along road. Equipment of all kinds requires careful attention and good treatment. The life of machinery depends upon repairs quickly made, lubricants and oils not too sparingly used, adapting the latter to the degrees of temperature—heavy oils in summer and light in winter. This demands particular attention, as the heavy oils will not run in cold weather, with the result that bearings are soon liable to be destroyed. The prospective purchaser will do well to bear in mind that bearings wear rapidly with the best of care and the ease with which they are removed is a consideration. Many manufacturers supply replaceable babbit bearings which can be changed in a few minutes. Other facts that should be borne in mind is the composition of jaws in crusher; manganese steel jaws are preferable, although costing several times the price of ordinary jaws, but outwearing several sets of the latter and demanding practically no attention. The size is also very important; a crusher running one hundred yards per day is absolutely essential. Manufacturers often insist that small size crusher will run this amount, but generally the opposite has been the result. Jaws approximately 12 in. x 16 in. to 10 in. x 18 in. have been considered correct size.

From the crusher, stone is carried to screen by bucket elevators. Little trouble has resulted with these; generally with attention and proper application of lubricant to keep running smoothly they will last as long as other equipment. The screen demands consideration and attention. Engineers and superintendents have in many cases purchased screens having three sizes of perforations, in ¾ in., 1½ in. and 3 in. This gives a ¾-in. to 1½-in. stone which, when applied alone, seems more detrimental than useful. The screen for limestone should contain two sizes, 1¼-in. and 3-in. respectively. Screens for trap should be somewhat smaller, approximately 1 in. to 2½ in. On many portable outfits the screen plates and elevator buckets are made of too thin material to wear well, the elevator buckets rusting quite rapidly. It is suggested that sprocket wheels and bevel gears should be made of manganese steel. The bin either of wood or steel with wood lining, should have a capacity of about 20 cubic yards, with three traps for loading stone into wagons.

The method of quarrying is particularly interesting. Often stone in limestone quarry may be removed a number of layers in depth with little or no blasting, then rock becomes firmer and powder or dynamite as a result becomes a necessity.

Drilling may be done either by hand, with steam or compressed air. Probably the two first named are methods most used in Ontario, although portable air compressor plants must soon make their appearance. The cost per foot of hole drilled by mechanical means approximates from 15 to 20 cents, using the ordinary tripod drill with 1⅛ and 1¼ bits, that by hand, from 35 to 45 cents.

Drills should be changed approximately every 15 ins., depending upon hardness of the rock. Dull steel makes a poor cutting implement.

Steam or air is not only cheaper than hand, but saves considerable man power, and work is carried on at much faster rate. The amount of road construction work to be done governs the size of plant and equipment that it will be required to purchase. Providing steam or air is used for drilling a portable boiler or air compressor is a necessary part of equipment. Sometimes the tractor providing power for crusher is of sufficient horse-power that it can also run the drill and probably hoist as well. The objection to this is, however, that it increases weight of tractor to an extent where it becomes cumbersome.

The explosive used to break up the rock which seems to give the best results is gunpowder or low freezing dynamite; they have a spreading and heaving action. Mistakes are often made in regard to producing rock for macadam. If the rock is hard and flinty a high explosive breaks it into pieces or spalls full of flaws, and then additional fractioning in a stone-crusher renders it unfit for heavy traffic, as it grinds down too quickly. A milder ex-

*Read before the Conference on Road Construction, Department of Highways, Ontario, 1916.

plosive causes fewer small fractures, and the life of the road is much prolonged.

Stone is generally moved from quarry face to crusher, either by dump cart, hoist or the old-fashioned wheelbarrow. The hoist is probably the most efficient, but in most portable outfits this does not exist and dump cart or wagon takes its place. Considering the latter two, the dump cart is certainly to be preferred; one horse will do the work of a team. Two or three dump carts at most can keep a crushing outfit working full capacity, with one man driving carts and two men feeding crusher. Dump carts are handy to handle in quarry, quick to unload, no time being lost on crusher platform, and generally more efficient than any other method of moving material, except probably in case of gravity method explained previously.

A raised platform should be built, slightly elevated above the crusher mouth, making it convenient to shovel in loose material and allowing the men to move stone from platform to crusher jaws without being required to lift it. The crusher should be run to its full capacity at all times and special care should be taken to arrange outfit that material may reach crusher and be taken away with the same speed. The efficiency of the operation of the outfit depends upon crusher, and as a result it demands greatest attention.

The traction engine to run the crusher will be required to develop approximately 20 h.p. and probably more, providing it is required to run the drill and hoist as well.

We must not think when speaking of the portable crushing outfit that its sphere of usefulness exists only in the quarry; far from it. Probably over 50 per cent. of the metal being applied to roads at the present time consists of crushed field stone or gravel. Field stone is used extensively in parts of Eastern Ontario and the northern counties, this stone being piled in winter convenient to the road. This is an economical method; labor is cheap and teams more easily obtained at that time. The stone should be piled in two rows, between which the outfit operates, the crusher being fed from both sides. Granite or trap boulders should never be broken with sledge after they have been placed in jaws of crusher; this not only has a detrimental effect on machinery, but helps to decrease the output. Crushed field stone makes good road metal, the only objection being its lack of uniformity. Crushed gravel is a metal which may give excellent service under medium travel. Pits containing coarse gravel which would not be used in its natural state on the road may be put through the crusher, fine and coarse together, and separated in screens, as other metal. The only extra equipment required is a wire dust jacket wrapped around part of the 1¼-in. section of the screen. This wire jacket of ⅜-in. size removes sand, dust and loam. This fine material should not be used on the road surface.

A method of feeding crusher operating in gravel pits which has found considerable favor in Western Ontario is by elevator buckets as used in ordinary crushing outfits. These bucket elevators are placed against bank of gravel pit and operated from crusher, material being fed directly into crusher jaws. Wheel scrapers are also used to bring the gravel on to the elevated platform and are probably as efficient as any other method. In this case, platform is built over jaws of crusher, and only one man is required to regulate the feeding.

The life of a quarrying and crushing outfit depends partly upon the local conditions, but principally upon the kind of material it has to handle. Field stone generally contains varieties of trap rock, limestone, sandstone, etc., all of varying hardness. The crusher operating under these conditions would be subject to greater wear than one working in quarry under practically no change. A crusher working in limestone would have much longer life than one in trap rock. Regardless of kind of material a crusher will depreciate rapidly if not properly handled; careful management will practically double the life. It has been estimated by some engineers that crushers will depreciate probably 16 per cent. and entire plant about 10 per cent. per season, but this, as stated above, depends entirely upon conditions under which plant operates, and no hard and fast rule can be made.

In conclusion, the different stages of quarrying operations have their own importance; stripping, drilling, conveying material to crusher, operating crusher with its equipment, all are a special problem in themselves. It is only after years of experience that a man becomes acquainted with all the kinks in quarrying and manufacturing stone. Efficiency in loosening material, in getting it to crusher and to wagons, mean low cost of road construction.

MONTREAL SEWAGE SUIT SETTLED.

In connection with city drainage into the Little St. Pierre River, a long-standing controversy between the city and the Harbor Commissioners has been settled in which the former's claim against the Harbor Board for $150,000, representing the cost of a new sewer, was dismissed.

The city, in its plea, submitted that it had, by law, an absolute right to conduct its sewers to the river; that the works executed by the Harbor Board, since 1890, were the sole cause of the nuisance leading up to the present case, and that in consequence the harbor authorities were responsible for the costs of effecting a remedy.

The Harbor Commissioners on their side denied that the city, either by common or statutory right, had authority to drain the waters from its territory into the river, and urged that if a nuisance resulted from this being done, it was the city's responsibility to effect a remedy. Even if it were to be admitted the city enjoyed the rights claimed, and even though the nuisance might have resulted from alterations in the harbor, the Harbor Board could not be held responsible, inasmuch as the works had been executed under the orders of the Federal Government.

Justice Martineau said the city had the right to drain into the River St. Peter, and from thence into the St. Lawrence, sewage from its territory; but, at the same time, it was within the rights of the Federal Government, which controlled the harbors, to execute in the port of Montreal all the works it believed necessary, and even if these works rendered the city's drainage impossible in those places, neither the Government nor the Harbor Board, to which it delegated the execution of these works, would owe any indemnity to the city. It devolved upon the city, and the city alone, to effect a remedy to any existing nuisance by placing the outlet of its drains lower down the river. Therefore the city's action was dismissed.

Incidentally, the harbor commissioners questioned the legal right of the city to drain into the river, but on this point the judge's ruling favored the city. Municipalities bordering on a river, he said, could conduct their sewers into navigable rivers in virtue of the right which every subject enjoyed of making such use of these waters as was not incompatible with their natural and public destination. But when it came to a question of conflict between the municipal and harbor authorities, as had arisen in the present instance, his Lordship found that the Gov-

ernment, as the controlling authority over the harbors, had the right to carry out such works as were deemed necessary without considering what effect they might have upon the city's drainage system in that harbor. If any nuisance resulted the city must effect the remedy and pay the entire cost.

COAST TO COAST

Toronto, Ont.—The Hydro-Radial Commission completed plans for a Toronto to Niagara Falls line.

Vancouver, B.C.—A prominent engineering firm is investigating the possibilities for the establishing of a modern steel producing plant.

Port Arthur, Ont.—The waterworks system has been transferred from the city council to the Utilities Commission as a measure of economy.

St. Thomas, Ont.—The annual report of the Hydro-Electric Company shows a surplus of over $9,000 after deducting depreciation charges.

Fredericton, N.B.—The St. John's River International Commission report, which has been in preparation intermittently since 1909, is completed.

Victoria, B.C.—The Saanich waterworks are now in possession of the council. The water was turned into the Saanich mains for the first time on February 18th.

Edmonton, Alta.—According to statements just compiled by the provincial government, the province has had 326 miles of railway constructed during the year of 1915.

North Vancouver, B.C.—The co-operation of Vancouver is sought by the Board of Trade in efforts to secure the establishment of copper and zinc smelters on the north shore.

Quebec, Que.—The Civic Health Committee, after investigating schemes for the purification of the city's water supply, recommended the adoption of a sterilization system.

Toronto, Ont.—At a meeting of shareholders of the Consolidated Mining and Smelting Co. it was decided to purchase the entire stock of the West Kootenay Light and Power Co.

Winnipeg, Man.—The sixth annual report of the Manitoba Good Roads Association shows that 265 miles of roadway were constructed under the Good Roads Act in 1915.

Edmonton, Alta.—At the convention of the Alberta Association of Local Improvement District and Rural Municipalities the formation of a Good Roads Commission was urged.

Calgary, Alta.—It is expected that when the auditors have gone over the accounts of the municipal plant the cost of paving done last year will be $2.50 or more per square yard.

Edmonton, Alta.—It is announced that the last spike in the construction of the Grande Prairie branch of the Dunvegan and Fort McMurray Railway will be driven on March 15th.

Winnipeg, Man.—Legislature proposes spending $25,000 investigating road conditions in the north. Dauphin will be the headquarters of the engineer in charge of the work.

Hamilton, Ont.—It is announced that the Canadian Northern will build a fast steam line from Toronto to Hamilton, and will drop its electric railway scheme, provided it is given greater bonding power.

Victoria, B.C.—The Department of Lands, Forests Branch, recently sent some fir and cedar ties to the Great Eastern Railway Company of England, who carried out tests which demonstrated the superiority of Douglas fir.

Mimico, Ont.—A joint meeting of ratepayers of Mimico, New Toronto, and Etobicoke will be held at which the municipalities will endeavor to decide on what terms they will agree to the completion of the Toronto-Hamilton highway.

Hamilton, Ont.—Although no action was taken by the Board of Trade at their special meeting, the arguments presented would indicate that the consensus of opinion strongly favored building an up-to-date steel bridge in place of the proposed fill over the marsh, connecting up the Toronto-Hamilton highway.

Sarnia, Ont.—F. A. Dallyn, provincial sanitary engineer, Toronto, reported to the council on Ald. Thomas Langan's scheme for supplying the city with a pure water supply. It was pointed out that the changing shore line and the high temperature of the water where Ald. Langan had planned to have the intake, would condemn the plan from a sanitary standpoint.

St. Thomas, Ont.—The Elgin County Council decided to pass a by-law to take advantage of the provision of the Highways Improvement Act in order to build good roads throughout the county. The by-law is not to become operative until January 1, 1917, and in the meantime a comprehensive plan will be prepared for designating the roads and the amount of improvements required.

THE WORLD'S SUPPLY OF POTASH.

For many years past the world's supply of potash has been in German hands owing to the fact that Germany possessed the enormous potash deposits of Stassfurt, which could produce potash more cheaply than any other locality in the world. The seriousness of this position is evident, since potash is an indispensable constituent of manures, without which modern agriculture could not be continued. In this respect the supply of potash is a matter which concerns everyone. Similarly, many British chemical industries, such as the manufacture of soft soap, alum, bichromates, glass, etc., depend for their continuance on supplies of poatsh.

In spite of the German potash monopoly the manufacture of potash compounds from other sources has lingered on in a small way in Scotland, Norway, France, Japan, Russia, and elsewhere, and in the last few years Italy and the United States especially, have endeavored to utilize new sources under their own control. Quite recently new deposits of salts somewhat of the Stassfurt type have been discovered in Spain and India.

The chief characteristics of manganese steel were summarized in a paper read before the International Engineering Congress, as follows: This steel usually contains 10 to 13 per cent. of manganese and approximately 1 per cent. of carbon. It is practically nonmagnetic and has a peculiar hardness, to which it owes a remarkable resistance to abrasion. It is extremely difficult to machine. It has high strength and toughness, but relatively low elastic limit. With care it can be forged and rolled. It has found its principal application in castings for crushing and grinding machinery and railroad crossings. Manganese steel has the peculiar property of being toughened and softened by quenching in water, resembling copper in this respect. All manganese steel castings are subjected to this treatment to remove brittleness.

Editorial

NEW ESTIMATE FOR CONSTRUCTION OF THE TORONTO-HAMILTON HIGHWAY.

Going into the history of the question as far back as the inception of this great work in the autumn of 1914, we find that the main object of the undertaking was at that time to give work to thousands of unemployed who otherwise would, to a greater or less extent, become a public charge. It was also thought that the work, which had been talked of for some time, could be done much cheaper at this stage owing to the abundance of labor. The latter, however, proved a fallacy, as the cost of labor, which was expected would have been less than 20 cents an hour, amounted to much over this.

The type of construction chosen originally was a two-course concrete centre, 16 feet wide, with shoulders of stone 4 feet wide on each side, making 24 feet of roadway.

The estimate of $600,000, as called for in the original pamphlet, did not take into account expenses of management, and plainly stated so. This item has been estimated at $56,000. In reference to the original pamphlet, one also notes the extremely low estimate for grading and ditching. Such an estimate could only have been approached in actual construction cost by a mere skimming of the surface.

The provincial highways engineer, when reporting on the original scheme, stated that the road could possibly be built for $650,000, exclusive of the cost of bridges and culverts, which item in the new estimate amounts to $88,000.

The Workmen's Compensation Act, which came into force since the work was started, is responsible for an additional $14,000. An item of $90,000 due to the employment of relief labor has been the cause of considerable discussion in the daily press, which is entirely uncalled for and not fair to either the employers of the labor or the laborers themselves, who for the most part were men who had been used to almost any other kind of work than pick and shovel work, and who, as before stated, would have been receiving help from the municipalities and not doing any work in payment if they had not been employed on the construction of the road. This item for $90,000 also accounts for the extra grading occasioned by cutting down the gradient and eliminating curves. Losses due to the inclemency of the weather are also chalked up to this account. Such additional costs as these would have been incurred by any contractor.

It was decided, after careful investigation and study, to change the concrete centre of the road to 18-foot width in place of 16 feet, as originally allowed for, and to substitute a 3-foot earth shoulder in place of a 4-foot stone shoulder. For this the commission accept the full responsibility. The estimated cost of this increase of 2 feet is $72,000.

These added items bring the estimated cost of the road up to $920,000. Admittedly it is high, being approximately $23,000 per mile, but if it means a really good road, and there is no good reason to doubt that, then it fulfils its purpose, and all interests should be satisfied.

The foregoing briefly accounts for the added cost of the road.

Up to October 31st, 1915, over $275,000 was paid out for labor, of which almost 50 per cent. went to citizens of Toronto. It is altogether likely that a goodly proportion of this is money that otherwise would have been expended in relief to these same citizens, not only of Toronto but of all the interested municipalities.

The commission has proposed a deviation of the road through part of York county. The reason for this is to leave undisturbed a 2-mile section of concrete roadway which would have to be torn up, as it could not withstand the heavy traffic of an inter-city road. Another reason is that the Lake Shore Road is not wide enough between the Humber and Etobicoke, being only 38 feet wide in some places where a width of 66 feet is required. This was not known at the time the Lake Shore route was decided on, and it would not be fair for the citizens of other municipalities to have to pay for this extra land. If the municipalities interested do not purchase the extra land then the commission should be allowed to choose an alternative route.

HYDRO-RADIALS IN PERIL.

The success of the hydro-electric railway scheme which was voted on this year seems to be somewhat in jeopardy, at least it will be if bills for extension of franchise of several Ontario electric railways are passed. One of these roads—the Toronto and Hamilton Railway—was incorporated in 1903 with a capital stock of half a million dollars. The company was given the right to construct a line of railway from a point in or near the city of Toronto to a point located near Hamilton. Among other concessions, the road was given power to buy or make agreements with a number of smaller companies. The road had bonding powers of $35,000 per mile.

The time for completion of the road was later extended to two years to commence and five years to complete. In 1906 the name was changed to the Toronto, Niagara and Western Railway, and capital was increased to six million dollars. It was given further power to enter into agreement with the C.P.R., G.T.R., and half a dozen Mackenzie lines. Time for construction was extended two years and again in 1909 a further extension of five years to complete the road was granted.

Another road—the St. Catharines and Toronto Railway—was incorporated in 1899 with a capital of one million dollars. In 1902, extensions of time were granted to several of its branches, and in 1905 the Toronto end of it was granted a further three years. This company also increased its capital to three million dollars and several more extensions were granted, bringing the time of completion up to 1915.

Now both companies are pleading for further extensions, their arguments being that they are unable to commence construction owing to the financial depression. But the same government granted them extension after extension before the war was on and they had no such excuse, so why should they be granted it now? The rights of the people should be respected; they have voted for hydro-radials and they are entitled to them. If the companies had built their lines as empowered by their franchises it is altogether likely that the hydro-radial scheme would never have been brought up.

PERSONAL.

J. D. McARTHUR, railroad contractor of Winnipeg, will join the board of the Winnipeg Electric Railway.

P. D. ROSS, of Ottawa, was named by the Provincial Hydro-Electric Commission as its representative on the Ottawa Hydro-Electric Commission.

W. G. MACKENDRICK, until recently with the Warren Bituminous Paving Co., is now a captain in the British army doing roadway work at Canadian headquarters.

H. P. BORDEN, C.E., has been appointed a member of the government commission in charge of construction of the new Quebec Bridge in place of C. C. Schneider, of Philadelphia, deceased.

M. M. INGLIS, of Winnipeg, has been appointed manager of the Port Arthur Electric Railway system and entered upon his new duties on February 1st. Mr. Inglis was formerly superintendent of the electric light plant at Yorkton, Sask.

H. F. WARDWELL, formerly home office manager, has been appointed general sales manager of the Detroit Steel Products Company, effective February 1st. He succeeds Mr. P. A. Smith, who recently resigned to enter another line of business.

CHAS. J. CROWLEY, well known in Toronto as a railroad engineer, and E. H. FITZHUGH, formerly vice-president of the Grand Trunk Railway, announce the formation of the Fitzhugh-Crowley Corporation, engineers and contractors, specializing in railroad work, with offices in New York.

OBITUARY.

ARTHUR P. SCOTT, engineer for the Snider Electric Furnace Co., died in Montreal recently. Mr. Scott was a graduate of McGill University in both arts and engineering. For some time after graduating he served on the staff as a demonstrator in science. Other firms with which he has been connected are: the Dominion Iron and Steel Co., and the the General Electric Co. He was 39 years of age. The news of his death has caused widespread regret in engineering circles.

ONTARIO LAND SURVEYORS.

Following are the officers elected for 1916 for the Association of Ontario Land Surveyors at their recent meeting in Toronto: President, Mr. C. J. Murphy; vice-president, Mr. James J. MacKay, of Hamilton; secretary-treasurer, Mr. L. V. Rorke; member of council and management, Mr. T. D. Lemay (two others to be elected by ballot); auditors, Messrs. A. E. Jupp and D. D. James.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the last meeting of the branch, held on February 16th, Mr. L. A. Thornton, C.E., addressed the members on "The Development of the Mountain Park Coal Fields." Mr. Thornton described the development of this field, which is situated 75 miles south of Edson on the G.T.P. He illustrated by numerous slides the various interesting features at the collieries as well as the wonderful natural scenery of the Rocky Mountains in that vicinity.

OTTAWA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a recent Managing Committee meeting of the Ottawa Branch of the Canadian Society of Civil Engineers, the following names were selected for submission to the Council of the Society at Montreal, in connection with representatives for district No. 4 on the special committee authorized at the recent annual meeting to consider ways and means of advancing the prestige and usefulness of the Society: Messrs. John Murphy, G. A. Mountain, James White, J. B. Challies, Col. W. P. Anderson, J. B. McRae, C. R. Coutlee, S. J. Chapleau, R. deB. Corriveau, and G. B. Dodge.

Of these names Messrs. White, Challies, McRae and Coutlee were unable to act, so that the three representatives for district No. 4 will be selected from Messrs. Murphy, Mountain, Anderson, Chapleau, Corriveau and Dodge.

At the request of the Managing Committee of the Ottawa Branch, Col. Maunsell, Director-General of Engineering Forces in Canada, has arranged a provisional school for officers desiring to qualify in military engineering.

The course consists of infantry training on two afternoons and one evening and lectures on military engineering on one evening each week. As a majority of the members are taking advantage of the course, it has been decided to discontinue the evening meetings of the Society.

Lectures delivered so far have been on "Military Bridging," by Lieut. Fellowes; "Duties of an Engineering Corps in the Field," by Col. Maunsell, and a paper on "Military Discipline," by Capt. Parker, who has been invalided home for some time.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

H. B. Muckleston, M.Can.Soc.C.E., has been nominated by the Calgary Branch and endorsed by the Edmonton Branch as one of the members representing district No. 6 on the committee to consider ways and means of advancing the prestige and usefulness of the Society, in accordance with a resolution adopted at the last annual meeting of the Canadian Society of Civil Engineers. Mr. Muckleston is a past chairman and at present member of the Executive Committee of the Calgary Branch. He has always taken an active interest in the affairs of the Society and will, if elected, make a valuable member of the committee.

VANCOUVER BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the regular monthly meeting of the branch, H. K. Dutcher addressed the members on the construction of the power plant at Kamloops. Lantern slides showing the character of the country and progress of construction of the plant explained more about this work.

COMING MEETINGS.

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION to be held at Sohmer Park, Montreal, March 6, 7, 8, 9 and 10, 1916. General Secretary, Geo. A. McNamee, New Birks Building, Montreal.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

THE CONSTANT ANGLE ARCH DAM

A NEW TYPE OF DAM IN WHICH THE ARCH TAKES THE GREATEST PORTION OF THE LOAD, EVEN CLOSE TO THE FOUNDATION.

THERE is a new type of arch dam to which more than ordinary interest is attached, on account of several new features introduced for the first time in the design. These features accomplish a double purpose. They introduce great economy and they also make it possible for the arch to take the greatest portion of the load acting as an arch even close to the foundation.

So far, the greatest objection of engineers to the use of a pure arch dam has been that this kind of dam as ordinarily built can not deflect enough at and near the bottom to take the load on the arch. Most of the load here has to be taken up by shear and cantilever action, and therefore material sufficient for this purpose must be provided. In the new type of arch the length of the upstream radius decreases at a more or less uniform rate from the crest towards the foundation. In the ordinary type of arch dam this length is kept constant, or in case the upstream face is provided with a batter, this length increases from the crest towards the foundation. That this difference in the length of the upstream radii of the two types has an important bearing upon the economies of the design should be easily realized, when it is considered that the thickness of the arch dam section is proportional to the length of the upstream radius at any elevation and that the crown deflection is practically proportional to the square of the length of the upstream radius. Therefore, the smaller the length of the upstream radius, the smaller the required thickness and the arch deflection. This is of especial importance towards the bottom of an arch dam.

Leaving for a later article the description of two particular dams of this type already in service, the general calculation of arch dams will be given here with especial reference to the type referred to.

In order to obtain a preliminary dam section for any given dam site the simple formula

$$t = \frac{P \times R_u}{q} \qquad - \quad - \quad - \qquad (1)$$

can be used for finding the thickness of a sufficient number of arch slices at different elevations; and by superimposing these slices upon each other the dam section can be formed. In this formula t equals the thickness of the dam in feet at any given elevation; P equals the water pressure in pounds per square foot; R_u equals the length of the upstream radius in feet and q equals the average stress in pounds per square foot of the area of the dam section (Fig. 1).

From (1) it is seen that the thickness, and therefore the area of the dam section varies in direct proportion with the radius. The volume of concrete in any arch dam is equal to the area of the section times the length of the mean arc. The length of the mean arc can be expressed as the length of the mean radius times the subtended angle in terms of

$$\pi \text{ or } V = \text{area} \times R_m \times 2\theta \qquad - \qquad (2)$$

where 2θ is the subtended angle.

The mean radius R_m equals half the width W of the span divided by the sine of half the subtended angle (Fig. 1). Thus

$$R_m = \frac{\tfrac{1}{2} W}{\sin \theta} \qquad - \quad - \quad - \qquad (3)$$

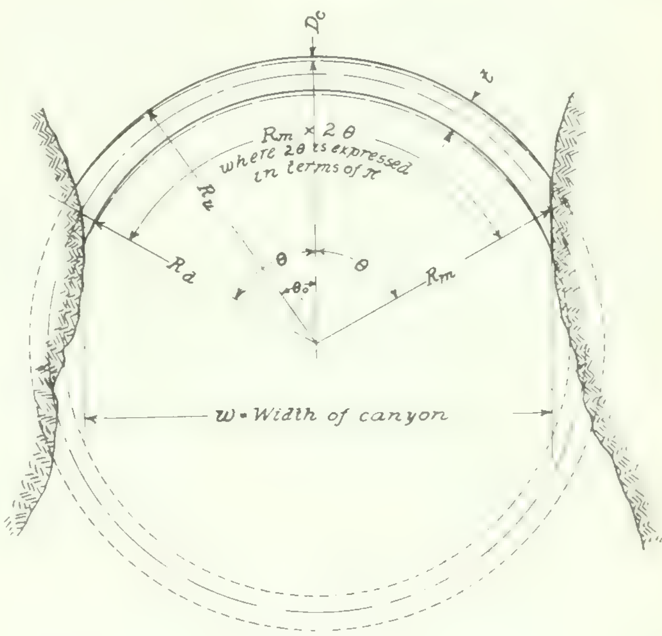

Fig. 1.

As the area of the section is proportional to the radius (both to R_u and R_m), (2), for the volume of masonry can be expressed thus:

$$V = C \times \frac{(\tfrac{1}{2} W)^2 \times 2\theta}{\sin^2 \theta} = \frac{K \theta}{\sin^2 \theta} \qquad - \qquad (4)$$

where C and K are constants, the latter depending upon the width of the canyon.

According to (4) the volume varies with the term $\frac{\theta}{\sin^2 \theta}$. The differential coefficient of this term equated to zero gives the minimum for a central angle of 133°, which means that any horizontal slice of the dam has the least volume when $2\theta = 133°$. In other words, the dam

contains a minimum amount of material when the central angle is kept 133° at all elevations.

The curve in Fig. 2 shows this graphically. The abcissas represent the central angle 2θ and the ordinates represent the term $\frac{\theta}{\sin\theta}$, the latter being proportional to the volume of masonry. In addition to showing the point of maximum economy, this curve also shows that as long as the subtended angle is kept above 110° the variation in the amount of masonry is very small, but below 110° the volume increases rapidly. Most all dam sites are narrower at the bottom than they are at the crest elevation; therefore, in order to place the material in the dam most economically, it is necessary to change the length of the mean radius of the dam continuously from the bottom to the top corresponding to the change in result, and the structure would be overhanging, which is impractical.

Whenever a certain thickness must be provided to prevent overhanging, it is most economical to increase the length of the mean radius above that corresponding to a central angle of 133° for the reason that a flat arch requires less material than a more curved one of the same thickness.

In the foregoing the thickness of different arch slices at different elevations have been determined, from (1), as if all the load were taken by the arch and the dam had no gravity action at all. How safe a dam would result depends primarily upon the unit compression allowed when using (1) for finding the thickness at different elevations. This design, however, would in most cases prove to be weakest in the middle, for the same reason that a long

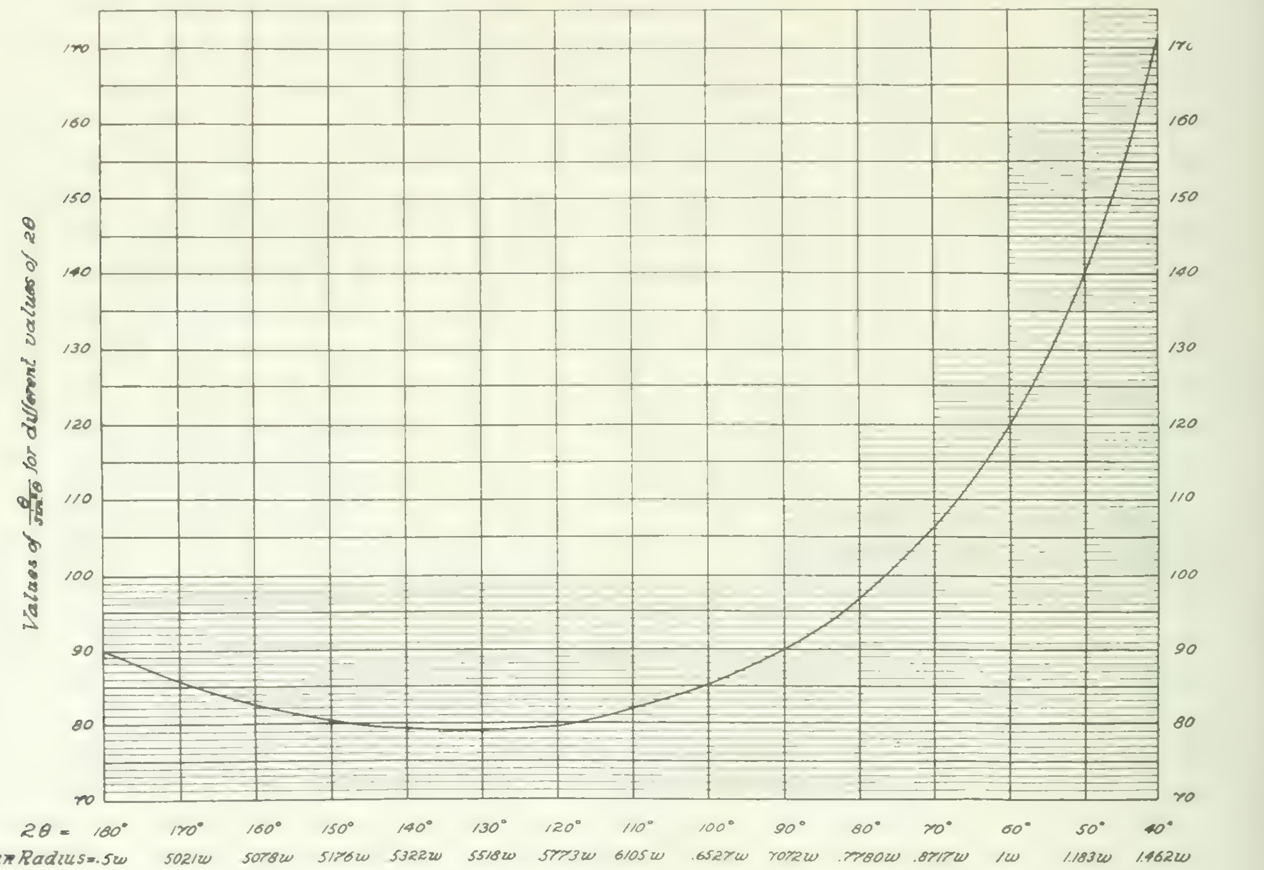

Fig. 2.

width of the site, so as to keep the subtended central angle constant. In practice it is seldom possible to keep this angle exactly constant. It is a mere ideal condition, but one should try to bring practice as close to theory as possible in designing the arch.

To prevent upper portions of the dam from overhanging lower portions, it will be necessary to have the thickness of the section increase from the crest towards the foundation. The proportional increase in water pressure must therefore be greater than the proportional decrease in length of the upstream radius towards the foundation. The ratio of increase in water pressure is always fixed, and the ratio of decrease in the length of the upstream radius depends upon the slope of the canyon sides. If these slopes are such, that at any intermediate elevation the ratio of decrease in length of the upstream radius has been greater than the ratio of increase in water pressure, a decrease in thickness of the dam at this elevation would column held at both ends is weakest in the middle and on account of having highest cantilever stresses here. Whenever t is small compared with R_u, the arch, when loaded, is practically a long column in compression, and the length of the arch should therefore not be over 25 times its thickness if the material is to be highly stressed. It is true that this circular column is supported to some extent along one side, but this added stiffness may be largely offset by the fact that the water may not soak through the upstream face uniformly, i.e., the effect of the water pressure would in all probability be unsymmetrical about the centre line of the dam. On a high, comparatively thin arch dam section, the resulting compression due to cantilever action and weight of material above may become excessive near the foundation requiring some additional material along the downstream face towards the foundation. The thickness of this added material should decrease vertically from a maximum at the foundation to zero at some higher ele-

vation and horizontally from a maximum in the middle, or the point where the deflection is a maximum towards the abutments. The thickening of the dam in the middle to take care of cantilever stress also stiffens the arch materially, considering it as a curved beam. It acts as such to a large extent towards the foundation where t is large compared with R_u.

Before attempting to find what proportion of the load is carried by the arch and what proportion is carried by the cantilever it must be determined how much of the total load is carried by the initial stresses in the arch.

By initial stresses are meant stresses principally due to the weight of the structure and to the water pressure. Therefore, these stresses reach their maximum values at or near the foundation and are zero at the crest. They have not been much discussed so far, but are very important and should be taken into consideration when attempting to find the actual division of load between arch and cantilever. When a body is compressed the dimension in the direction of the compressive force becomes smaller, but in other directions the body swells if free to move (lateral strain). The ratio of lateral to longitudinal strain for concrete has been taken $\frac{1}{m} = \frac{1}{5}$ in the following calculations.*

Any horizontal layer of material will have to sustain compression corresponding to the height of masonry above it and will therefore actually become shorter in a vertical direction and have a tendency to expand horizontally. If the abutments are unyielding the arch may be prevented from actually becoming longer, in which case axial compression is introduced the same as if water pressure acted upon the structure.

If the specific gravity of the concrete for the dam is taken at 2·3 and the height of the dam H, then the average vertical pressure can be expressed as $\frac{2 \cdot 3 . H}{a}$; where a is the ratio of total height of dam to height of a rectangular wall having the same sectional area and the same base. The ratio a is known as soon as the section is known, and in dam design the section must be more or less determined before final calculation can be made.

The dam section in Fig. 3 has an area of 9,668 feet, a base width of 70 feet, and a height of 250 feet. The height of masonry column causing the mean vertical pressure is, therefore, $\frac{9668}{70} = 138$ feet and $a = \frac{250}{138} = 1 \cdot 81$; making the mean vertical compression upon the foundation in terms of head of water equal to $\frac{2 \cdot 3\, H}{1 \cdot 81} = 1 \cdot 27\, H$, with no water pressure upon the upstream side.

The condition of full reservoir introduces an additional force, viz., the radial water pressure, tending to compress the dam body in a direction perpendicular to the direction of the compressive force due to the weight of the body. At the bottom of the dam this force is equal to H in case the water is standing to the crest of the dam. In this case the radial water pressure tends to counteract the swelling of concrete in an up and downstream direction (due to the weight) thereby introducing additional initial axial compression. The total resulting initial axial compression at the foundation of section shown in Fig. 3 is therefore (in terms of head of water):

$$1/5\,(1 \cdot 27\, H + H) = 0 \cdot 454\, H \qquad - \qquad (5)$$

where Poisson's ratio has been taken equal to 1/5.*

The height of water, h, that this initial axial compression of 0·454 H will resist without causing any shortening of the length of the arch at the bottom can be found by using (1), thus:

$$h = 0 \cdot 454\, H \frac{t}{R_u} \qquad - \quad - \quad - \qquad (6)$$

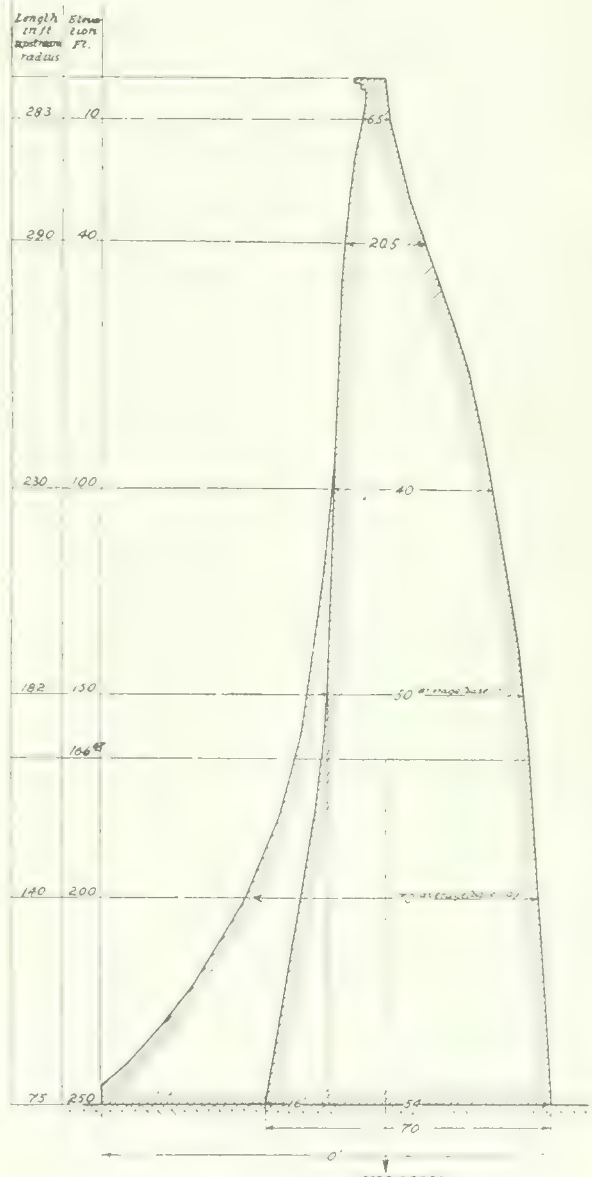

Fig. 3.

For the narrower section, shown in Fig. 3, $t = 70$ feet at the base and $R_u = 75$ feet. Substituting these values, it is seen that this section at the very bottom is able to carry $h = 0 \cdot 454 \times H \times \frac{70}{75} = 0 \cdot 425\, H$, or 42.5 per cent. of the total head of water as an arch before any shortening in the length of the arch occurs.

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*Prof. C. von Bach has been kind enough to make some tests for the writer to determine m for concrete 1:2:3. He found for specimens 45 days old, using between 0.1 and 24 kg. per sq. cm. compression, m to be 5.3. See also Bach's Elasticität und Festigkeit, 5 Auflage Seite 301. Considering that large stone will be embedded in the concrete in most dams the factor 5 has been used for m as probably representing most closely actual conditions.

*Mr. H. Ballet was probably the first to point out the necessity of taking Poisson's ratio into consideration when attempting to find the actual stresses in dams. See Proceedings of the Institute of Civil Engineers, 1909, Page 51.

The initial axial compression holds in equilibrium the stresses due to 42·5 per cent. of the total head at the bottom, the remaining 57·5 per cent. of the load will divide between cantilever arch and curved beam action in proportion to their relative carrying capacity.

By analyzing (6) it is seen that by simply varying t or R_u, or both, the designer can utilize more or less of the initial stress to carry the load. If the base thickness in Fig. 3 is increased from 70 feet to 110 feet and the thickness increased correspondingly at higher elevations, the initial stresses will be able to support at the foundation $0{\cdot}4 \times H \times \frac{110}{75} = 0{\cdot}585 \times H$, or 58·5 per cent. of the total water pressure before any shortening in the length of the arch occurs and before additional axial compression is introduced.

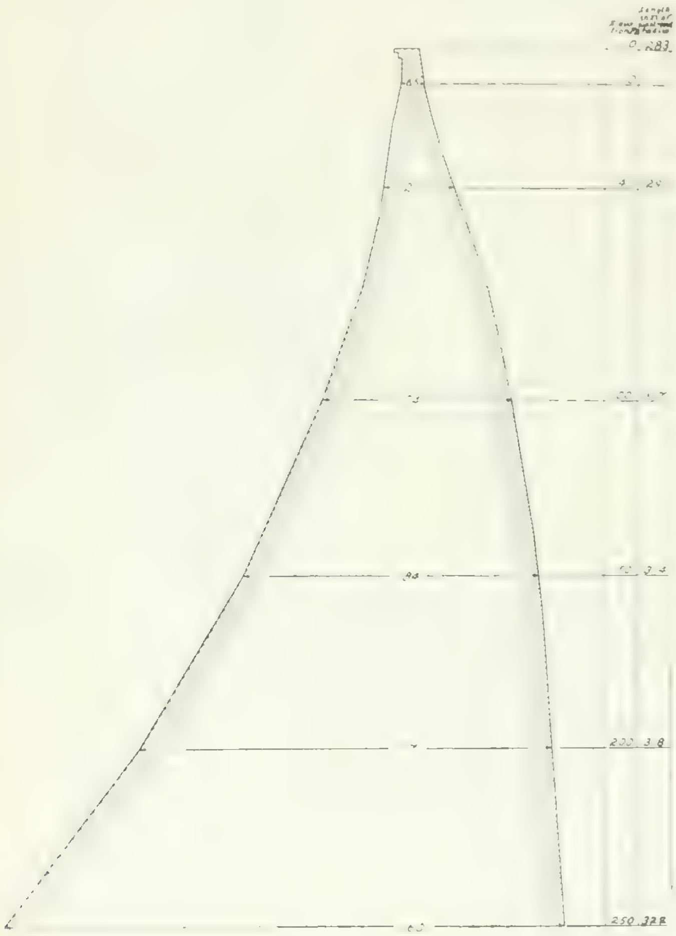

Fig. 4.

When the arch, however, becomes very thick in comparison with its length, the load is carried more by curved beam action than by ordinary arch action.

The dam shown in Fig. 3 was designed with varying radii to keep the central angle of the arch as nearly constant as possible at all elevations. For comparison, a section is shown in Fig. 4, using the same unit compression except where the section is wider than a gravity section near the foundation and the same upstream face batter, but a single common centre as ordinarily used for both upstream and downstream faces. For this section the length of the upstream radius is also variable, but it increases towards the bottom and reaches here a value of 322 feet. (See tables of lengths, Figs. 3 and 4.) The initial stresses in this dam will resist 20% of the head of the water at the bottom. It is, therefore, easily seen that the constant angle arch is much more effective in utilizing the initial stresses to carry the load than is the ordinary arch dam struck from a single centre. If a gravity section is insisted upon for the arch, but the central angle kept as near constant as practicable it will be possible for the gravity section to take up the greater part of the load acting as an arch and curved beam. The factor of safety has thereby been largely increased.

For finding the arch deflection the following formula has been used:

$$D_o = \frac{C\,C_o \times P_1\,(\text{upstream radius})^2}{E\,t} \qquad (7)$$

where $P_1 = p\,\frac{R_u}{R_m}$, and $C\,C_o$ is a factor which takes the curved beam action into consideration and can be directly found from Fig. 5.*

Formula (7) has been used for finding the deflection curves A and B (Fig. 6) of the two sections, Fig. 3, (base 110 feet), and Fig. 4. Formula (6) has been used for correcting these curves A and B to take the effect of lateral strain into consideration. These curves represent the deflection of the two arches assuming they are free to move at the foundation. They are plotted to show how evenly the deflection, curve A, slants from a maximum near the top to nearly nothing at the bottom in the constant angle arch type, Fig. 3, and how little the slant, curve B, amounts to in the ordinary type of arch dam, Fig. 4. These curves also show very plainly that from the common arch type much arch action towards the bottom cannot be expected; cantilever and beam action must take the load since no such deflection as 0·2624 in. could be possible at the point where the arch is fastened to the rock foundation. The constant angle arch type for this particular site requiring only 0·0083 in. deflection, 31·5 times less to support the same load will take most of the load upon itself acting as an arch.

For dam sites where the abutments are close together towards the foundation and where t is large compared with R_u, (7), gives the values for the crown deflection which are too large, even assuming that the dam is entirely free to move at the bottom. While this formula considers the curved beam action, it is at the same time understood that arch action is complete. However, where the arch is thick and the distance between the abutments short, the arch becomes a wedge and the horizontal curved beam takes the greater proportion of the load, as acting in this manner the support of the same load will require a smaller deflection. The deflection in the middle of a beam 1 foot wide held at both ends and uniformly loaded is:

$$D_b = \frac{P l^4}{384\,E\,J} \qquad (7A)$$

The notations are the same as before, P being the unit water pressure, l the length of the beam, E the modulus of elasticity of concrete and J the moment of inertia using like units.

Whenever (7A) gives smaller values than (7) it is indicated that arch action is incomplete. The curved beam action tends to introduce axial tension along the downstream face in the middle and along the upstream face near the abutments, but the axial compression due to the partial arch action and lateral expansion (Poisson's ratio) will or should much more than compensate for this tendency. If it does not, the design should be changed.

*This Fig. and Formula (7) are reproduced from a discussion by Mr. Shurtleff of a paper entitled, "Lake Cheesman Dam and Reservoir," Transaction American Society Civil Engineers, 1904, page 80. E is the modulus of elasticity and t is the thickness.

From curve A the deflection of the arch (Fig. 3) at the ⅓ point can be directly ascertained. It is found to be 0·132 in. If the cantilever 250 feet high and 1 foot wide were actually forced to deflect 0·132 in. at this point (Elev. 166·67 feet) a force, F, would be required which can be found as follows (F is concentrated at the ⅓ point):

$$D_c = \frac{n F l^3}{E h^3} \qquad (8)$$

In (8) (taken from standard handbooks) the value of n depends upon the rate of variation of the face slopes. If both faces were vertical n would equal 4. If the faces (or at least the downstream face) were shaped as flat parabolas, or if the thickness of the section in an upstream and downstream direction at the one-third point was approximately half the thickness at the foundation, n would equal 8.

This last condition is the one that theoretically best fits cases in dam construction. Considerable modifications are mostly necessary, however, due to the fact that the rock foundation itself, to some extent, takes part in the movements of the dam body. With a full water load the rock foundation under the middle portion of an arch dam moves more in a downstream direction than does the ends, as the push in a downstream direction is the greatest in the middle and as at the ends, only a component of the axial compression acts in a downstream direction. Therefore, the cantilever can not take up as great a proportion of the water load as it would if fastened to an immovable foundation and more load is therefore thrown on the arch. The writer has for some time been trying to find a practical value for n by analyzing deflection data obtained from actual dams. He thinks he is justified in using $n = 12$ for solid rock foundation, and 16 for seamy rock foundation. This makes (8) empirical, but the results from it are believed to be closer to actual facts than any results arrived from mere theoretical conditions on account of the number of assumptions it is necessary to make.

Inserting the value of 12 for n in (8):

$$D_c = \frac{0.132}{12} = \frac{12 \times F \times 83.33^3}{432,000,000 \times 110^3}$$

$F = 911,000$ lbs.

The cantilever will deflect the same as the arch when thus loaded.

The total water load on a vertical slice of the dam, 1 foot wide and 250 feet high, is $250 \frac{0.15,625}{2} = 1,953,125$ lb. The initial stress supports $1,953,125 \times \frac{16.4}{100} = 320,312$ lb. before any deflection takes place. Therefore the load causing a deflection of 0·132 in. of the combined arch and cantilever must be equal to $911,000 + 1,953,125 - 320,312 = 2,543,813$ lb. The proportion of this amount taken by the cantilever will be $\frac{911,000}{2,543,813} = 35.8$ per cent.

Now, the actual load to be divided between cantilever and arch is not 2,543,813 lb. per running foot, but only $1,953,123 - 320,312 = 1,632,813$ lb. Of this amount the cantilever carries 35·8 per cent., or $1,632,813 \times \frac{35.8}{100} = 584,547$ lb., concentrated at the one-third point, making the actual deflection at this point $0.132 \times \frac{64.2}{100} = 0.0847$ in.

The bending moment due to this force is equal to $584,547 \times 83.33 = 48,710,301$ ft.-lb.

The section modulus of the base $\frac{110^2}{6} = 2,011$, and therefore the compressive stress on the foundation at the toe, due to the bending action of the water load on the cantilever, is equal to

$$\frac{\text{Bending moment}}{\text{Section modulus}} = \frac{48,710,301}{2,011} = 24,222 \text{ lb. per sq. ft.} \qquad (9)$$

The total compression on the foundation at the toe will be this compression added to that due to the weight of the structure, which amount to approximately 16,200 lb. per sq. ft. at the toe, making the total compression approximately 40,400 lb. per sq. ft.

If a base length of 70 ft. is chosen, the arch would take a greater percentage of the load and the curved beam a smaller, leaving the same or less for the cantilever, but, owing to the smaller section modulus of the 70-ft. base, the compression at the toe would be somewhat higher than 24,222 lb. per sq. ft., and the compression due to the weight of the structure would be much higher than

$$CC_c = \frac{\frac{2\sin\theta}{\theta}(1-\cos\theta)+\frac{1}{2}(\cos 2\theta-1)}{\frac{3\theta}{\sin\theta}+\cos\theta-4}+(1-\cos\theta)$$

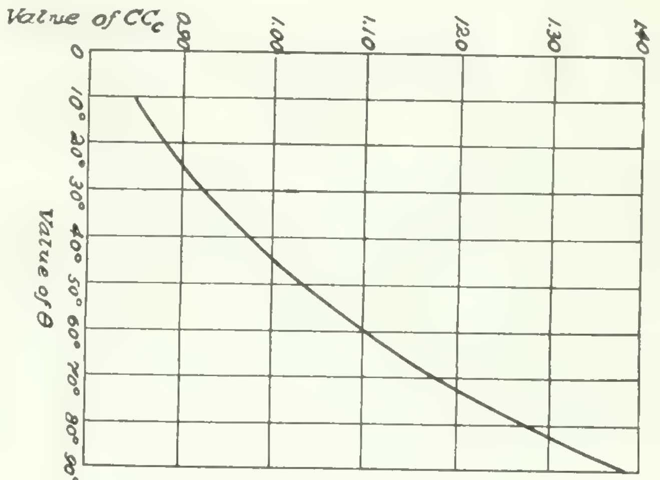

Fig. 5.

16,200 lb. per sq. ft., so that the sum of the two would be considerably more than 40,400 lb. per sq. ft. Although within the safe limit, the resulting vertical compression would be somewhat out of proportion to the 36,000 lb. per sq. ft. (and less) axial compression used when calculating t from (1).

The dam section with the 110-ft. base contains only 4% more material than the dam with the 70-ft. base (Fig. 3), as the addition is not made as a portion of a circular ring, but in the shape of a spherical triangle. Any intermediate base length between the two limits given in Fig. 3 could be accepted for a dam built on this particular site. The two stresses (the 36,000 lb. per sq. ft. average axial compression, and the maximum 40,400 lb. per sq. ft. vertical compression) are acting in planes perpendicular to each other, and therefore tend to support each other. Although they are low, the resulting section (Fig. 3) appears slender on account of the economical distribution of the material.

This method of calculating the vertical stress upon the foundation is correct only so long as no tension exists at the heel, or if tension exists, as long as this tension is properly taken care of. For the constant angle arch,

where the cantilever takes the smaller proportion of the load, there will seldom be occasion for tension along the upstream face, and there will perhaps never be enough tension to demand consideration. The accuracy of the result obtained from 8 depends to some extent upon the face slopes, especially the downstream face slope. The error, however, is generally such as to compensate for the error made in not considering that the width of the vertical cantilever, which is 1 foot at the upstream face, is less at the downstream face. The short-cut method explained above for finding the division of the water load between cantilever and arch action, and from that for finding the total maximum foundation pressure, cannot be used for dams having a crown deflection curve similar to line B (Fig. 6), as this line does not show a maximum deflection near the crest, and a zero deflection at the foundation. Deflection curve A answers these conditions closely enough for this purpose.

Only the middle or highest dam section has been considered, as we are mostly interested in knowing the most dangerous stresses in the structure, which stresses generally occur, in high dams at least, at the toe with reservoir full.

In (1) only average stresses have been considered in determining the thickness of each individual arch slice. The maximum axial stresses should also be investigated. These exist along the downstream face and are found from the formula,

$$Q_{max} = q \frac{2 R_u}{R_u + R_d} \qquad (10)$$

However, (10) does not give correct results towards the foundation where the arch is thick relative to the length of the upstream radius, and where the span is short. The proportion of the load carried by the arch in such a case is supported more by the curved beam than by ordinary arch action. This will cause some difference in the value of Q_{max} and q_{min}, as found from (1), adding to Q_{max} at and towards the abutments, and subtracting from Q_{max} in the middle portion between the points of contra flexure on the curved beam. These points are located thus:

$$\cos \theta_0 = \frac{\sin \theta}{\theta} \qquad (11) \text{ See Fig. 1.}$$

In high dams Q_{max} will ordinarily be lower than the vertical compression at the toe; therefore, this vertical pressure is still the most important to investigate. The influence of initial stress (Poisson's ratio) tends to equalize Q_{max} and q_{min} in dam sections having upstream faces of steeper slope than their downstream faces. In such sections the vertical pressure due to the weight of material above is greatest along the upstream face, and therefore the initial axial compression is also greatest. It is fair to assume that this condition of relieving Q_{max} and adding to q_{min} also tends to improve the watertightness of the dam.

In all straight gravity dams built across narrow canyons, horizontal tension exists along the downstream face in the middle, and along the upstream face near the abutments, at least toward the foundation. This should be very plain when it is considered that any beam fixed at both ends and uniformly loaded will support four times as much load as a cantilever of the same length sustaining the same water load (nothing at the top and a maximum at the bottom). In other words, whenever the beam is four times longer than the cantilever, it will support one-half of the total load, and whenever this ratio is less than four, the horizontal beam will support most of the load. The ordinary gravity design does not consider this beam action, although when the dam is built in a fairly narrow canyon the greatest portion of the load towards the foundation is actually carried on the horizontal beam and not on the cantilever. While adding materially to the stability of the dam (as long as the horizontal tension introduced by this beam action is not above the breaking

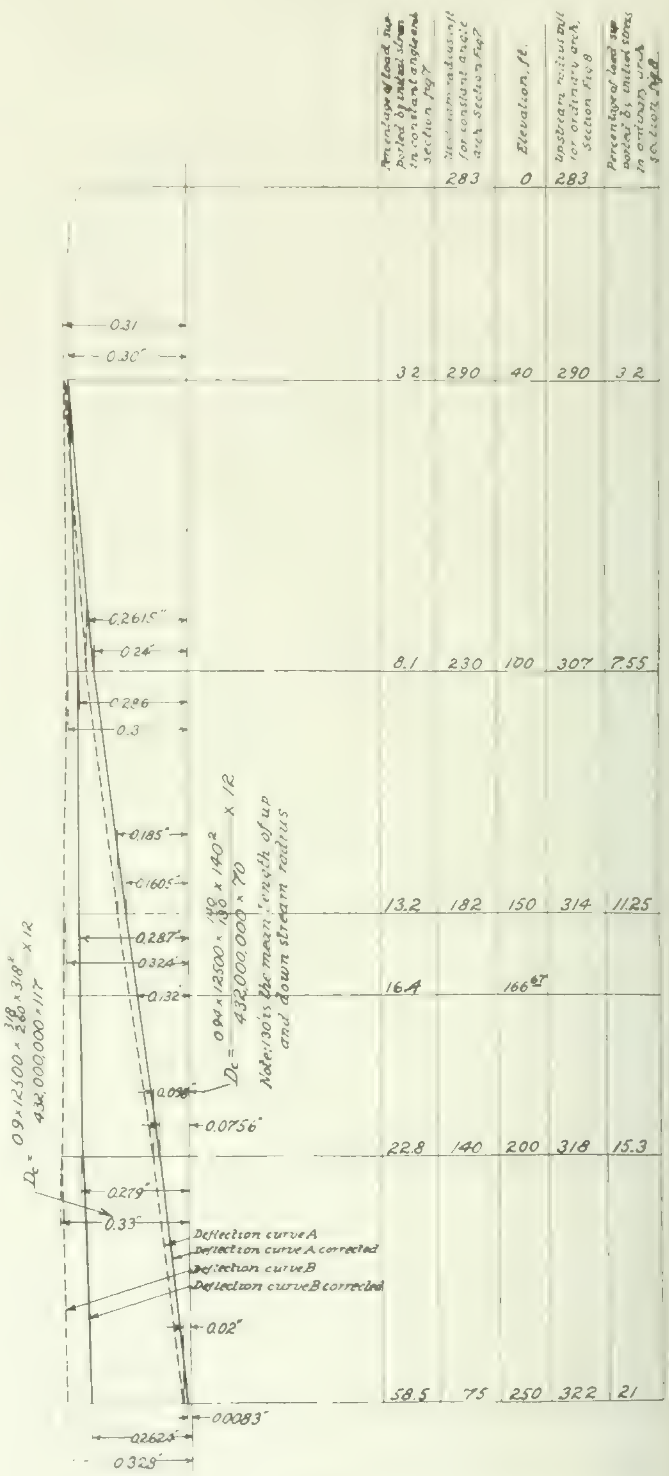

Fig. 6.

point, and as long as the expansion joints, if any, are placed at or near the points of contra-flexure only) the foundation pressure at the toe is at the same time much relieved, a very welcome feature, especially in connection with high dams.

Now, if the horizontal beam be curved, axial compression takes place over the entire section, and the greater

the curvature, that is, the smaller the length of the upstream radius, the more load will be taken by the arch, and the less remains to cause horizontal axial tension at any point of the dam faces, due to beam action. The resultant axial compression from arch action and lateral expansion will, in general, more than compensate for this tension. Lateral expansion due to the weight of the structure exists, of course, whether the dam is straight in plan or curved, but this alone will seldom be sufficient to compensate for the horizontal tension due to beam action in a straight gravity dam across a narrow canyon. The curvature must be introduced to be sure of no tension existing in this horizontal beam. For a dam 250 feet high the bottom width of the canyon would have to be well towards half a mile before a gravity dam would act simply as a gravity section towards the bottom, and before the influence of the horizontal beam action would be negligible unless it should have failed in tension first.* It would, therefore, seem logical to provide even quite long dams with a slight curvature sufficient to take care of the horizontal tension.

Whenever load is supported on a beam or on a cantilever, shearing stresses are introduced. These shearing stresses reach their maximum values at the foundation and at the abutments, and should be investigated in order to be sure that they are within safe limits. In the case of dam section shown in Fig. 3, base 70 feet, it can easily be shown that even should the shear on the lower 50 feet of the dam correspond to the full water pressure, this stress would be entirely within the safe limits, amounting to approximately 4,000 pounds per square foot. Along this joint the maximum unit compression generally exists. This compression is so much larger than the shear that actual shear cannot take place, as friction alone will prevent any tendency of sliding at the abutments. Crushing would have to take place before actual sliding of any element could occur.

Before concluding the general discussion the action of changes in temperature should be considered. As the ends of the arch are fixed to the abutments, the shortening or lengthening of the arch due to temperature changes either causes cracks to develop or forces the crown back and forth. In the constant angle arch type the average crown deflection for the same amount of decrease or increase in length or arch is only about one-half of that required by the common arch type, (See curve A and B, Fig. 6) and the tension or compression necessary to cause this deflection or pulling back of cantilever may therefore not exceed the ultimate strength of the concrete, in which case no cracks would develop. In any event cracks are not so liable to occur as in the common arch type of dam.

*Near the top the horizontal beam would have no practical influence.

The Quebec Government is determined to reduce the number of forest fires in the Province, and legislation with this end in view has been introduced by the Honourable Jules Allard, Minister of Lands and Forests. The changes about to be made, briefly summarized, follow: First, that all persons between the ages of 19 and 50 may be called on to aid Government officials in fighting fires, and must respond to the call of the Government in such cases, unless they can submit valid reasons for refusing to serve as fire fighters. For each day they work for the Government in fire fighting they will be paid $1.50 to $2. Another amendment aims to reduce the danger of fires from railway trains. It will be required that timber limit holders shall clear the trees from each side of railway tracks for at least a distance of 100 feet. The third change provides that settlers will be prohibited from clearing timber in summer months without a permit from the Government forest ranger.

MAPS AND PLANS FOR HIGHWAY ENGINEERS AND SUPERINTENDENTS.*

By T. M. DeBlois, S.B., Assoc.Mem.Can.Soc.C.E.

ONE of the important divisions of highway engineering, and in fact of any branch of engineering, is the accumulation, the proper classification and the convenient recording of data of interest or importance to the engineer.

Maps and plans, in connection with a highway organization, might be classed in the service department. No matter how thoroughly the operations of a highway department may be systematized, where those in charge of the different units of the organization are dependent upon daily consultations and studies of the records on file to enable them to picture in their minds the progress of the work under their jurisdiction, there is always a certain amount of lost motion which would be eliminated if all available information and a continuous record of operations were indicated on properly prepared maps and plans.

As road maps, the original township survey maps, at a scale of one-half mile to the inch, filed with the Provincial Survey Branch, are of little use, as the great majority were prepared long before many of the roads were in existence. These maps, however, do give the frontage and area of the lots, and naturally form the background of other maps which have later been prepared, showing the divisions of the land into concessions and lots.

In connection with the township maps of Ontario, we notice that many have more or less regular systems of jogs along the side roads, which follow similar systems of jogs in the lot lines midway between the concessions. This irregularity is due to the inaccuracy of the compass survey. For example, the surveyor runs his line and places his posts at regular intervals along the concession road, going from one concession road to the next. If his chainage were accurate and his lines run truly parallel, a lot line run at right angles to the concession road would obviously hit the corresponding post on the adjacent concession road. However, when a later surveyor stakes out the lots on the ground he finds that lines run from each concession line at right angles do not meet at the centre of the concession, and to rectify the error the lot line jogs to make a closure. Still later, when the side road is laid out, it must either make the corresponding jog or run through the property of the lot owner.

However, the most complete road maps of the whole province are those issued by the Department of the Interior at Ottawa, known as the Standard Topographical Maps. The maps are at a scale of 3.95 miles to the inch, and show the plan of the province from Windsor to Montreal in sheets about 28 inches wide. These sheets show the roads in double line as accurately as can be shown at such a small scale.

While the standard topographical maps of the Department of the Interior have been referred to as the most complete for the whole province, the one-mile-to-the-inch maps of the Department of Militia and Defence covering that portion of Ontario from Kingston and Ottawa to the eastern boundary of the province, and from Toronto and Buffalo to the western boundary, supply us the most accurate information regarding the limited portion they cover, that are at our disposal. These maps locate all roads and streets, lakes, rivers and creeks, bridges and

*Read before the Conference on Road Construction, Ontario Department of Highways.

culverts, buildings, wooded areas and swamps, etc., etc., and are traversed by contour lines at 25-foot intervals.

The military maps are dependent upon surveys conducted by that department, to as fine a degree of accuracy as can be reproduced on a map at the scale of one mile to the inch. The control, which goes to make up the framework of the maps, is procured from triangulation, chain, transit traverses, transit traverses with bicycle along railways, and stadia transit traverses, and is based upon points established in Canada along the shores of the Great Lakes and River St. Lawrence by the United States Coast and Geodetic Survey; also geodetic surveys conducted by the Department of the Interior at Ottawa.

Our Department of Highways has prepared a complete set of county maps of Ontario at the scale of one mile to the inch, showing roads in double line, lots, rivers, railways, etc., and also practically a complete set of township maps at double the size of the county maps, namely, one-half mile to the inch. These maps have been compiled from the best available sources and are being corrected as later information is obtained.

As a suggestion of a few of the uses to which these maps can be put, the following is submitted: First of all it would be advisable to adopt a standard legend to show the exact character of every piece of work locating the county road system, whether concrete, macadam, gravel or earth which has been only shaped and crowned or which has not been shaped or crowned or otherwise improved. A standard legend should also be prepared which will show the character of construction of every sluice, culvert and bridge, which should be plainly numbered, and these numbers used in all reference, by correspondence or otherwise, to these structures.

The matter of standardization of this legend is important. The maps in possession of the various branches should be so characterized that the information contained on them can be immediately read by any engineer familiar with the legend.

A further use to which the maps can be put is to mark on them the history of the roads in the various townships. For instance, the year in which the road was opened, the nature of the material, when the improvements were made, and the nature of the improvement. The history also could be given of the various important culverts and bridge structures. Those structures which had depreciated to the extent where it would be advisable to have them replaced could also be shown.

All these uses that can be made of county and township maps, some of which have been suggested, others which may have special application to particular localities, will perform a distinct service to the road engineer or superintendent. They will serve to keep before him in a manner that should be comprehensive and clear, a complete picture of the history and actual conditions of the highways in his particular locality. By so being in touch with the men who are familiar with the different localities, the department will thus be enabled to improve and bring to a higher state of accuracy our township and county maps. This point is important, for, while many of our maps are obtained from accurate sources, yet with many of them there are necessarily errors both of "omission and commission" due to a scarcity of information at our disposal, and which, by the means suggested, would thus steadily be improved.

For the opening or extension, or indeed the improvement of roads, the importance of preparing a plan and profile of the right-of-way cannot be over-emphasized.

If a man proposed to build himself a house, he first of all considers as a self-evident necessity, the preparation of complete plans and details of his proposed dwelling. This in order, first, that he may estimate his costs, and secondly, that he may have the processes before him of the construction from the cellar to the roof of his finished building. For similar and very obvious reasons, the building of a highway should be accompanied by a plan and profile of the proposed right-of-way. It further would be a valuable record to the county engineer to keep a profile of the more important roads in his county. With this record he can see at a glance the various hills and grades, and in the event of improving that road and incurring the reduction of some of the grades, proper estimates can be prepared and the problem can be approached in a systematic manner.

SOME HINTS ON THE APPLICATION OF SEWAGE TO CONTACT BEDS.

In the annual report of the New Jersey State Board of Health, Francis E. Daniels describes the methods of applying sewage to contact beds as practised at Essex Falls and Plainfield. At these plants the tank effluent is applied on the top and at one corner of the contact beds. From a small area at the point of application, from 6 in. to 1 ft. of the contact material is removed from the top of the beds and the excavation is filled with fine cinders. An embankment about a foot high is constructed of the same material around this area so that all the tank effluent that is applied to the contact beds strains through the cinders. A great deal of suspended matter is thus removed from the tank effluent, and the clogging of the body of the bed is materially reduced with a corresponding increase in the effective life of the contact beds.

With the growing practice of reducing the storage capacity of sedimentation tanks, the value of underfed contact beds is diminishing. With a long period of tank storage, the tank effluent is usually very septic and contains considerable quantities of offensive gases. With a tank effluent of this nature, odors are probably reduced by having contact beds of the underfed type. With the present practice of constructing sedimentation tanks so that the storage period is reduced, the effluent as a rule is not septic, and offensive gases are not present to any great extent. In such a case the overfed contact bed is preferable to the underfed type.

In the overfed type of contact bed it is maintained that the use of distribution troughs or pipes to distribute the sewage over the surface of the beds is inadvisable. These troughs distribute the clogging suspended material over the whole surface of the beds, and sometimes require considerable cleaning and attention.

The cinder straining areas not only prevent, to a large degree, the clogging of the whole surface and body of the bed, but they serve as an index of the operation of the sedimentation tanks. The scum accumulating on these areas can be removed from time to time between doses. The rapidity with which the scum forms will serve to indicate to the attendant whether or not the tanks should be cleaned.

An interesting point was brought up recently in the Iowa Supreme Court, when the right to use water in a reservoir or pond conveyed to a railroad company was reserved to the land owner. The latter's animals so polluted the water that it was unfit for use in locomotives, the purpose for which the railroad desired it; and the railroad fenced the pond. The landowner sued in equity to enjoin the fencing and for damages. The court holds that in such a case each party must exercise his rights with reference to the rights of the other, and the landowner could not allow his stock so to pollute the water. The railroad, however, could not exclude the landowner from all use, but should apply to the courts to restrain the pollution.

WOOD AS A PAVING MATERIAL.*

By W. Kynoch,
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DURING the past decade there has been a steadily increasing interest among municipal highway engineers in the possibilities of creosoted wood block paving for city streets. The history of creosoted wood block paving has not been free from failures, but it may be noted with satisfaction that these failures have been made the subject of careful observation and experimental study, not only by those associated with commercial interests, but also by independent technical investigators. As a result, the causes of many of these early difficulties have been located, whether in methods of treating blocks or in design and construction of pavement, and improvements in practice have been made accordingly.

It may be of interest to quote from statistics compiled and published by the United States Forest Service. In 1909, the total amount of timber treated as paving blocks for use in cities of the United States was 2,994,290 cu. ft., equivalent approximately to 1,150,000 sq. yds. of pavement. In 1914, the timber treated for this purpose was 6,869,370 cu. ft., equal to about 2,617,000 sq. yds. In 1911 the reported area of creosoted wood block pavement in service in a number of the larger representative cities of that country was as follows: New York, 650,000 sq. yds.; Chicago, 700,000 sq. yds.; Minneapolis, 950,000 sq. yds.; Indianapolis, 500,000 sq. yds., and Cincinnati, 375,000 sq. yds.

Referring to the present use of wood block paving in England, and more particularly in London, as the world's greatest metropolitan district, it is interesting to note that creosoted wood block paving has there reached its most successful development. The significance of this statement can be appreciated fully when the traffic conditions of some of the principal thoroughfares of London are understood. Henry W. Durham, chief engineer of the Bureau of Highways, Borough of Manhattan, New York, commissioned in 1913 to make a personal investigation of paving materials and pavement construction and maintenance in European cities, in a report recently published, notes with reference to the wood block pavements of London, " . . . a large extent of soft-wood pavements on its principal thoroughfares. (Borough of Westminster). The last are probably the finest pavements in the world. Particularly good is that on Parliament Street and Whitehall from Parliament Square to Trafalgar Square. It carries a heavy traffic, principally motor omnibuses and other motor vehicles. Having less traffic but a very extensive one of pleasure vehicles of all classes is the Mall, extending from the Admiralty Arch at Charing Cross to Buckingham Palace. This is also wood block on concrete foundation and presented the nearest approach to a perfect street surface observed anywhere."

Untreated wood block pavements were in use in England at least eighty years ago. In the United States and Canada such pavements, generally built of round cedar blocks, were quite widely used as early as 1850, and some cases of such pavements were to be found as recently as fifteen or twenty years ago. These blocks were laid on plank foundation or in some cases on macadam foundation only. These pavements obviously could not be entirely satisfactory, but they served a useful purpose during a certain development period in the United States and Canada. Later, untreated rectangular wood blocks were adopted. This was an improvement in some respects, but early failure of such pavements from decay of blocks was the inevitable result. Later the development and more general use of preservative treatment of wood suggested the application of such treatment to wood paving blocks.

According to first methods of treatment adopted for this purpose, blocks were dipped in hot creosote oil. Such treatment resulted in the absorption of from two to four pounds of oil per cubic foot of timber. This marked a distinct improvement in practice, and such dipped wood pavements may be considered the immediate step toward the development of modern creosoted wood block paving. Considerable areas of dipped block pavement were laid in United States and Canada with satisfactory results. There are such pavements still in service in Canadian cities, many of which are now in good condition. It may be of passing interest to note that there are several dipped wood block bridge floors in the city of Ottawa, laid from six to eight years ago, which have given good service, and are at present in very satisfactory condition. However, the general adoption of pressure methods for impregnating timber with preservatives naturally led to the use of pressure treated paving blocks. Absorptions of creosote up to 20 pounds per cubic foot may be obtained by such methods, and with the heavier impregnation of preservative, the protective value of the treatment is obviously very much increased. The creosote oil injected within the block serves the double purpose of protecting the wood from decay and acting as a waterproof filling material. Pressure treated blocks are now used universally for wood paving, and it should be understood that claims made in this paper for creosoted wood block paving, refer to such methods of treatment.

A brief description of the present commercial methods of treating paving blocks may be of interest. Blocks are cut from 3-in. or 4-in. stock, varying in width from 5 ins. to 10 ins. The stock is planed on one side to insure a straight edge, and is cut on gangs of small circular saws on which provision is made for adjusting saw spacing, according to the depth of blocks required. In American practice, blocks are cut in 3-in., $3\frac{1}{2}$-in. and 4-in. depths, according to the requirements of traffic conditions for which they are to be used. The sawn blocks from the gang pass to conveyer, where defective block—those under size or showing heavy checks, loose knots or decay —are removed. Inspected blocks are carried by conveyer to cylinder block cars. These block cars are from 7 ft. to 9 ft. long, of cylindrical shape, 5 ft. to 6 ft. in diameter, mounted on narrow-gauge trucks. Cars are made with perforated steel plate sides and closing cover to prevent blocks floating out in retort. Commercial pressure treating retorts or cylinders are usually $6\frac{1}{2}$ ft. to 7 ft. in diameter and from 120 ft. to 130 ft. long. They are designed for working pressures up to 250 lbs. per square inch, although operating pressures during treatment of timber seldom exceed 160 lbs. to 175 lbs. per square inch. Retorts are charged with a train of loaded block cars. The capacity of a commercial retort of typical size is from 1,800 to 2,100 cu. ft. of paving blocks, equivalent approximately to 600 to 700 sq. yds. of 4-in. block pavement.

After blocks are charged into retort they may be subjected to a preliminary steaming at temperatures ranging from 225 to 240 degrees F., for a period of from 1 to 3

*Abstract of a paper read January 19th, 1916, at Ottawa, before the Canadian Lumbermen's Association.

hours, as may be required. If this feature of treatment is adopted, it must be followed by a vacuum drawn in the retort up to 20 ins. or 24 ins. mercury. Exhausting the retort after steaming is for the purpose of evaporating the water and withdrawing a part of the air contained within the wood. Preliminary steaming and vacuum before the admission of the preservative to the retort, is not always specified in the treatment of paving blocks. However, results of an experimental investigation by C. H. Teesdale at the United States Forest Products Laboratory, Madison, reported in a paper presented at the eleventh annual convention of the American Wood Preservers' Association, January, 1915, indicate that these features of treatment are desirable for blocks of some species at least. After steaming of blocks and exhaustion of the cylinder, or in some cases, as above noted, without any such preliminary treatment, creosote oil, previously heated to a temperature of from 170 to 200 degrees F., is admitted to the retort, the pressure applied gradually until the desired absorption of preservative has been attained, as indicated by gauges on oil stock tanks. The oil is then withdrawn from the retort and, if desired, a subsequent short steaming period may be included in the treatment, for the purpose of cleaning the surface of the blocks. A final vacuum, after the injection of the preservative, for the purpose of withdrawing excess of oil from the wood, is a feature of one proprietary method of treatment which has been extensively used in United States and Canada with good results.

The preservative used almost universally for paving blocks treatment is coal tar creosote oil—either a straight distillate product of coal gas or coke oven tar, or more generally, in present commercial practice, a mixture of such distilled oil and filtered tar. These mixed "paving oils" are now extensively used for paving block treatment in America, and it is probable, if they meet the requirements of approved detailed specifications as to methods of production, composition and physical properties, that they are as satisfactory for this purpose as the higher priced straight distilled oils. The absorption of oil in paving-block treatment, with the exception of Douglas fir blocks, is generally specified to be from 16 to 20 lbs. per cubic foot in correct American practice. While absorptions of 20 lbs. per cubic foot were formerly generally required, the recent general tendency is toward somewhat lighter impregnations—16 to 18 lbs. per cubic foot. The writer is inclined to believe that absorption of from 14 to 16 lbs. per cubic foot are sufficient for some Canadian woods for which heavier treatments have heretofore generally been specified. An absorption of 10 to 14 lbs. per cubic foot is the usual standard for the treatment of Douglas fir blocks.

The design and methods of construction of wood block pavements are in general similar to those of brick or other block pavements, although certain features have been developed to meet the special conditions. A concrete base is laid 5 ins. to 6 ins. in thickness, conforming in general to the contour of the finished pavement, usually with a crown allowance of 8 ins. on a 50-ft. street width. On this a ¾-in. cushion of a 1 : 3 cement-sand-mortar is spread dry and struck off with a template or spacing strips. This cushion is sprinkled in advance of the placing of the blocks. These are laid with the grain vertical, in straight paralleled courses, which may be at right angles or inclined to the street line. A ¾-in. or 1-in. expansion joint is allowed at each curb and a single or double course of header blocks placed parallel to the curb line. After laying, blocks are rolled to surface with a steam roller, and block joints filled with a suitable bituminous filler material. This is generally specified to be an asphalt cement or a mixture of coal tar pitch and asphalt. This material must be carefully squeegeed into joints to a depth of at least ⅔ the depth of blocks. The finished pavement is covered with a light layer of clean sand, which cleans the surface of the excess of filler and oil, and incidentally is partially worn into the blocks by traffic, forming a resistant wearing surface. A thin cement grout washed over pavement after pouring bituminous filler is frequently used as an additional means of securing a clean surface.

It is unnecessary within the limits of this paper, to offer any more detailed description of methods of treatment of wood paving blocks or design and construction of pavement, all of which are covered in carefully developed specifications adopted by various municipal and highway engineering associations. Such approved specifications may be safely adopted, either entirely or with modifications to meet local conditions.

The initial cost of wood block paving is fairly high as compared with some other widely used types of pavement. The cost of completed pavement will range from $2.50 to $3.80 per sq. yd., varying with the depth of block used, and with local conditions. Actual cost figures from construction of wood block pavements in Eastern Canada are: $2.75 to $3 per sq. yd. for 3-in. block pavement; $3 to $3.40 per yard for 3½-in. pavement, and $3.25 to $3.70 where 4-in. blocks are used. On the Pacific Coast the cost of wood block pavements is somewhat lower than that indicated by the above figures. Transportation charges on treated blocks and the cost of actual pavement construction are the more important variable factors, and these may be estimated closely for any particular local condition. However, admitting the relatively high first cost of wood block paving, it must be realized that ultimate cost, estimated on service performance, and not initial cost only, is the fair and logical basis of comparison of various paving materials.

With reference to the various wood species which have been successfully used for creosoted wood block paving, it may be noted that a considerable number of woods have been proved to be adapted to such service. In England, Baltic pine has been used most extensively and with excellent results. In the United States, the woods now in general use for paving are southern yellow pine, Norway pine, Douglas fir, hemlock, tamarack and black gum. In Canada, Norway pine, Douglas fir and tamarack have been used most largely, and with good results. In the Canadian West, Douglas fir and possibly hemlock and tamarack will furnish the supply of timber stick for wood paving, and it is safe to assume that there will be a marked increase in the use of these woods for such purpose. In Eastern Canada, the logical choice of native timber for paving block stock is Norway pine. This species is so well known to members of this association that descriptive comment is unnecessary. However, it may be of interest to note that in structural and physical characteristics this wood resembles rather closely the Baltic pine of Europe, the merits of which for wood paving service have been so conclusively demonstrated in England. Norway pine, as previously noted, is already widely and favorably known as a wood paving block timber, both in the United States and Canada, and the growing recognition of its merits for this purpose will undoubtedly lead to its much more general use in this country. It is not improbable that creosoted hardwood blocks may be adopted to some extent for paving purposes in Canada. At present the limited records of service performance of creosoted hardwood block pavements are hardly sufficiently conclusive to warrant any confident prediction as to developments in this direction.

OLDEST IRRIGATION CONDUIT AND DAM IN THE UNITED STATES.

ON the meadows beside the lower San Diago River, half a dozen miles northeast of the City of San Diago, is the old San Diago mission. Here the Catholic missionaries, working northward from Mexico, established near the end of the eighteenth century one of the first outposts of civilization on the Pacific Coast in what is now United States territory.

In this arid region, with a rainfall averaging only about a dozen inches per annum, all occurring in the fall and winter months, irrigation is a prime necessity to agriculture. There still stand in a remarkably good state of preservation the dam and a large part of the conduit by which water was diverted from the San Diago River and carried some miles down its valley to the ranches surrounding the mission. There is little doubt, according to Engineering News, that this dam and conduit are entitled to the distinction of being the oldest irrigation works in the United States or Canada, with the exception, of course, of the more or less primitive works for irrigation carried on by Indian tribes prior to European settlement. When one bears in mind the extreme limitations in means of transportation, in material, labor, and money with which these Catholic pioneers had to contend, the building of the old Mission dam and conduit was a remarkable achievement.

The dam, it should be explained, is purely a diverting dam and not a storage dam. The San Diago River in its course of some 50 miles descends from elevations of 3,000 to 5,000 ft., and the river and its tributaries have eroded deep canyons in the soft rocks of the region. At its flood stages the river carries a very heavy burden of sand and silt, so that the pond back of any dam built across it is filled full with solid material during the first flood season.

It is of interest in this connection to record that prior to 1850 the San Diago River carried annually vast quantities of silt into San Diago Bay and was rapidly filling up the present harbor of San Diago. It was due to the genius of a distinguished officer of the Corps of Engineers that San Diago harbor was saved for commerce. During the years prior to the Civil War, Lieut. Geo. H. Derby, of the Corps, who was stationed on the Pacific Coast, made himself famous by writing humorous papers which were published under the *nom de plume* of John Phoenix. Lieutenant Derby proved that he was as competent an engineer as a humorist by diverting the course of the San Diago River at its mouth, so that instead of discharging into San Diago harbor it was made to empty into what is known as False Bay, a shallow body of water located to the north of San Diago Bay and separated from it by a high sand ridge.

Fig. 1.—The Oldest Irrigation Dam in the United States, Built by the Old Mission of San Diago, Cal.

The old Mission dam and the conduit, as may be seen by the accompanying illustrations, were built of a curious combination of rough rubble masonry and very large, thin tile. The mortar used was, of course, lime mortar and must have been burned in kilns established for the purpose near-by. As may be judged from the views of the dam and of the flood which it annually sustains, this lime-mortar masonry has lasted remarkably well. The central opening in the dam, seen in the view, doubtless originally contained a wooden controlling gate which was left open in time of flood and was closed only when it was desired to divert the water into the irrigation conduit, which connected with the dam near its north end. One reason for the location of the dam at this point is that the river here flows over bedrock at the head of a long canyon, so that all the flow down the valley is intercepted by the dam. In

recent years the dam has been used as a river-gauging station by the United States Geological Survey.

From the dam the masonry conduit follows down the north bank of the river about three or four miles to the lands around the old mission. Much of the conduit is still plainly visible from the highway on the opposite bank. The construction of the conduit is shown in the accompanying cross-section drawing. Over a part of its course,

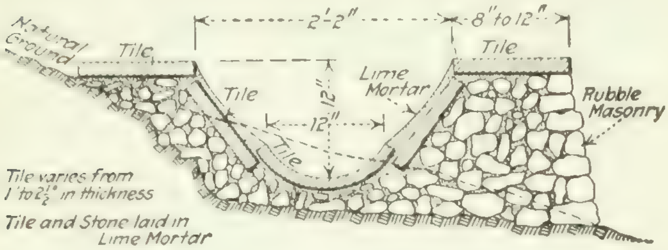

Fig. 2.—Typical Cross-section of Old Mission Conduit Near San Diago, California.

however, the conduit was in excavation and appears to have been merely lined with masonry. The size of the tiles used for lining is particularly noteworthy and evidences the considerable ability of these early pioneers in the art of pottery manufacture and in utilizing Indian labor for this more or less technical work.

DISCUSSION ON ECONOMIC AND STRATEGIC ASPECTS OF ENLARGEMENT OF WELLAND CANAL AND OF CONSTRUCTION OF GEORGIAN BAY SHIP CANAL.

At a general section meeting of the Montreal Branch, Canadian Society of Civil Engineers, Col. W. R. Leonard presented his paper on "Economic and Strategic Aspects of Enlargement of Welland Canal and of Construction of Georgian Bay Ship Canal." Colonel Leonard stated that he had prepared this paper four years ago while in the government service, and that it was not intended as a criticism of any government in Canada.

The paper, a resumé of which appeared in last week's issue of *The Canadian Engineer*, was then read, being illustrated by maps and plans of the Ottawa Ship Canal which, the lecturer stated, were not intended to boom that work in any way.

Written discussions were read, one by J. S. Armstrong, who referred to the haste with which the paper was to be dealt with—which haste has been overcome by the postponement of the reading of the paper for one week.

A written discussion by Mr. F. H. K. Wicksteed, of Toronto, then was read. Mr. Wicksteed stated that water transportation was not always cheaper than rail, and only in the case of our great inland seas could it compete with the railroads. Canal routes, he stated, were not cheaper than rail. Mr. Wicksteed said that there is no basis for the fear that the enlarged Welland Canal will carry a preponderance of United States freighters into Lake Ontario, giving them the control, because they will make more money running from Lake Superior ports to Lake Erie ports than if they went to Oswego. Regarding the Georgian Bay Ship Canal, he stated that a certain gentleman in Detroit said that the canal was not thought of as anything but a joke. They would not send their 600-ft. steel freighters through the Georgian Bay Canal because they would lose money.

Discussion then followed as to relative freight rates via rail and water over various routes.

He stated in reply to Col. Leonard's query as to whether the United States would bear their share of enlarging the St. Lawrence system to divert the trade from Troy and New York to Montreal, that he thought it was only a matter of approaching the United States government and asking for a convention or to appoint a joint commission. He was certain that they would ask for one-half the water power, as called for in the International Waterways Treaty.

Mr. Wicksteed did not agree with Mr. Leonard's statement that the deepened Welland-St. Lawrence Canal would be found to have probably three times the length of actual excavated canal and about the same length of restricted river navigation as compared with the Ottawa route. He said the figures for the excavated channel and canal on the Ottawa route were 94 miles and three times this would be almost 300, and the peculiarity of the Ottawa-Georgian Bay Canal is that there is no great length of unrestricted continuous navigation in it. The maximum continuous stretch of navigation on the Ottawa route is about 32 miles. He produced a map showing these features. Another point is that no matter what our inland transportation may be, we are going to be limited in the amount of grain or other bulk products we can ship via the St. Lawrence route by the transportation facilities from Montreal to Europe.

So far as our present canal systems are concerned, the Welland and the St. Lawrence, it has been demonstrated beyond question that the boats that are now in the trade, and particularly those that have been built with a view to that traffic, can carry grain from Lake Erie to Montreal at lower rates than the railways can carry it from Georgian Bay ports to Montreal. By the time the cars are loaded at Georgian Bay and made up into trains there is a good deal of cost involved, but when they reach Montreal they go into the terminal here where they have to be broken up and the freight carried down to meet the steamship and then the empty cars brought back and made up into trains and the terminal expense is very high. They will always be handicapped in that way as against the steamship which can float right alongside of another steamship and transfer its cargo. Therefore, the greatest economy can be attained in transportation by employing vessels of, say, ten to twelve thousand tons on the lakes and transferring the cargoes at the entrance to the canal to the types of vessels adapted to go through the canal, and again unload and transferring the cargo to ocean-going ships. It will never be possible to build a type of ship that will be economical to run from the head of our lakes to British ports.

Sir John Kennedy stated that it was the first time he had heard the paper and was not prepared to discuss it. However, he agreed with one point in Col. Leonard's paper and that was that the whole question should be thoroughly studied by a commission.

Mr. White quoted some comparative rates for freight via rail and water which Mr. Jamieson said were rather misleading, as they did not take terminal costs into account.

Mr. Leonard made the statement that his paper was written so as to get the Canadian Society of Engineers to look upon these questions and the expenditure of public money as part of their business and to discuss the matter in their own Council.

Col. Leonard was accorded a hearty vote of thanks for his paper.

COST-KEEPING AND EFFICIENCY IN ENGINEERING.

IN modern engineering construction the question of how much a dollar will do is one of vital importance. The necessity of cost-keeping enters as largely into general engineering and contracting as into industrial business. Shrewd judgment, rule-of-thumb or the knack of "coming out on the right side" are not the factors in success that they may have been in the past. Costs are as important to the engineer as to the manufacturer.

No one cost system can be designed that is of universal applicability—each engineering task has its own individual peculiarities, and demands an independent treatment and natural development. The success of a system depends to a large extent upon the executive whose brain and administrative ability must plan and put into execution methods of reducing cost: the cost records are merely a guide post on his path. In the installation of a system, time and persistence are important elements; while its successful operation requires loyal co-operation from all subordinates.

The following useful discussion of the fundamental principles are requisites of cost-keeping as applied to engineering construction, is from a lengthy paper on the subject in Vol. viii., No. 37, of "Professional Memoirs" of the U.S. Army, by Lieut S. C. Godfrey, Corps of Engineers.

Tredgold's definition of engineering, "the art of directing the great sources of power in Nature for the use and convenience of Man," has been so often quoted as to become classic; but to-day it is no longer permitted to pass unchallenged. Wellington came much nearer the revised conception of engineering, when he spoke of it, in his "Economic Theory of the Location of Railways," as "the art of doing well with one dollar that which any bungler can do with two after a fashion." The great engineering works of antiquity, many of which were of monumental character, like the pyramids, were built with scarcely any regard for cost. The substantial highways and aqueducts of the later Roman days expressed more of the spirit of commercialism. To-day, more than ever before, considerations of economics play a vital part in every constructive enterprise. The engineer finds himself ever in closer touch with industrialism. One day his scientific knowledge may be applied to the appraisal of public utilities; the next, he is asked to decide the advisability of an investment, or the type and magnitude of a contemplated structure. Again, he is chosen by a municipality, like Dayton, to act as its city manager. In short, he is constantly compelled to go beyond his formulas for stresses in order to answer the question, "Will it pay?"

Efficiency in engineering construction may be defined as accomplishing a given task in the most expeditious, most economical, and most substantial manner practicable. This does not mean, of course, that the cheapest practicable structure is sought. A Gatun dam may be designed with such emphasis on security, with such large factors of safety, as to make its cost necessarily high; but the dam, once designed, is built with the effort to secure, by means of efficient methods of construction, the maximum return for each dollar expended. Now, efficiency is no new invention; but modern industrial conditions have made efficient methods well-nigh a requisite for success. With the increasing discussion and amplification of this subject, the term "scientific management" has become a watchword, and "efficiency engineer" a term with which many have hoped to conjure. Under the guidance of elaborate systems and detailed rules worked out by Mr. Taylor and other experts, shop management has become highly standardized. The application of these principles to field engineering, where the work is of a very different and less specialized character, has been far less widely made; yet much has been done in this direction as well. Cost-keeping systems have been put into successful operation; and although such systems have been far from proving universally successful, their failure, where they have failed, has been due to some weakness in the system or the man operating it, rather than in the principle involved.

Principles of Cost-keeping.—The essence of the question of costs is extremely simple. Man is in business for profit. The margin between the cost of the product he makes or builds and its selling price is the measure of his success. Thus cost is fundamental; and the successful business man, whether he be a manufacturer selling automobiles, or a contractor building a dam, has been the man who, prompted perhaps merely by business instinct and shrewdness, watched and estimated his costs closely. Now, a good cost system should place in the producer's hands a tool far more powerful than any rule-of-thumb methods; for it replaces his guesses by exact knowledge, points out leaks and wastes, establishes standards for comparison, and gives data for future plans and estimates.

This raises at once the question as to what constitutes a good system of cost-keeping. The requisites of such a system may be summed up by saying that the records should be: (1) Reliable; (2) Simple; (3) Immediate.

Reliability.—This is the first essential. If it is not fulfilled, the records may be misleading, in which case they are worse than useless. For this reason all sources of cost must be weighed,—so-called "cost data" are often misleading because they involve simply field cost, without consideration of such factors as depreciation of plant. Figures must be carefully checked and proved, estimates of work to be done compared with measurements of actual performances, the whole tied into, and checked by, the general accounting scheme. The impossibility of mathematical accuracy, on any extensive work, is apparent, when the factors of overhead expense are considered. It is a question rather of practical accuracy, and this is by no means out of reach.

Simplicity.—The cost system should not be too complicated—a requirement which many systems, as designed, fail to meet. The system must be installed, be it remembered, in most cases, in the face of inertia and perhaps opposition on the part of subordinates who are adherents of a system, or lack of system, already in operation; and must be operated, perhaps, by these very subordinates. Then, too, the labor and cost of the system itself, with its considerable clerical work, must be carefully considered with reference to the results it is expected to attain. In particular, the reports should not demand much clerical work from men in the field, foremen and others, to whom such work is distasteful and whose efficiency may be impaired thereby.

Immediateness.—In order to be of practical value, the cost records must be available before the information they portray is cold, while there is still time to act on it. Of little use, at the end of a season, to put one's finger on a leak that should have been stopped way back in midsummer. Yesterday's mistake should be found out in time to plan to-morrow's work. This requirement necessitates that the records be kept up-to-date and frequently posted at stated periods, so that their information will be promptly available. Here appears an additional argument for simplicity, for the more simple the system the easier it should be to obtain prompt returns.

The Test of Usefulness.—If the cost-records meet these three requirements, they will be pretty sure to be used and not neatly filed away on a shelf to gather dust. They will present in concise form just the information the executive needs to keep him in touch with the work. They should be well arranged and summarized, with such standards for comparison as "average cost to date," for example. Of course, the reports should show unit costs, and these should be accompanied by such descriptions of the particular circumstances of the work—climate, distance from railroad, labor conditions, etc., as will make them of permanent and not merely temporary value. The cost system dovetails into the methods of purchasing, the functions of inspectors and their reports, the system of administration. In short, it should present an intimate and ever-changing view, a moving picture, as it were, of the entire project.

Units.—Closely allied to the requirement of accuracy is the question of the choice of proper units in which to express the cost-records. Care and uniformity in regard to their use are essential. For instance, the standard unit for concrete is the cubic yard; but concrete sidewalks are usually expressed in terms of square feet, and so any comparison or transformation from one unit to another is misleading unless it involves the thickness of the sidewalk. Round piles may be described in terms of linear feet, while at the same time sheet piles are called for in feet board measure. Units of length, commonly applied to drilling, pipe laying, etc., and units of area, used in painting, paving and similar work, are in general easily chosen. Volumes are much more difficult to determine with any degree of precision; recourse must be had, in the absence of careful surveys, to estimates of performance, to such records as the number of batches of concrete mixed, and to discrepancies in the stock-pile showings, etc. Measurements of weight are frequently the most suitable, as for steel and dynamite. Other units involve a combination of the simple terms; the ton-mile as applied to transportation and the man-hour in connection with labor are prominent examples. In measuring economic efficiency of performance, the dollar must be used with caution as the unit of comparison. Prices for raw supplies, for labor, fluctuate widely; conditions vary infinitely; and cost-records can be considered of comparative and permanent worth only when they are expressed in such units as to eliminate or at least explain these fluctuating factors.

Classifications.—In devising a system of records for any elaborate engineering work, the need of classification is strongly felt. Thus the different work-operations, the raw materials, the finished products, the workmen themselves, may any and all be subjected to this systematizing process. Not only are a better organization and grasp of detail made possible thereby, but in the records themselves, by the use of proper symbols, economy of time and space may be gained. The systems most commonly adopted are modifications of the familiar decimal classifications of Melvil Dewey's; the use of numbers is sometimes supplemented by that of letters. The whole subject is a fascinating one; such classifications, however, should be designed and applied cautiously. A too complicated and cumbersome classification defeats the very ends it aims for; in the field, especially, there is danger of too much elaboration. The fundamental requirement of simplicity must be kept in mind.

Forms.—In designing forms and record blanks, again, the first requisite is that they be simple and readily understood. It must be remembered that they are but a means to an end, and must not be allowed to become a fetish. As one writer has tersely put it, "About half the blanks and forms of the ordinary business system are merely confetti whereby those who are a lap behind can follow the trail of the live ones." Forms should also be made out with reference to the man who has to fill them out; a foreman will take infinitely more pains and interest in making out a report if it obviously leads somewhere, if it has a purpose that he can understand.

Cost-keeping vs. Bookkeeping.—It has been said above that the cost system should be tied into the general accounting scheme. The question arises, "how does cost-keeping differ, if at all, from bookkeeping?" The answers have ranged all the way from the statement that cost-keeping is merely "intelligent bookkeeping" to the assertion that "cost-keeping should not be allowed to interfere in any way with the bookkeeper's work." Somewhere between these two extremes lies the true relation. The bookkeeper's figures should, perhaps, tell the whole story. His tendency, however, is to confine himself to debits and credits, to the balancing of accounts with mathematical precision. The engineer uses the same figures, but uses them to lay bare the engineering aspects of the job. He is interested rather in quantities of materials, in unit costs, in efficiencies of performance, and must devise the means of obtaining such data. Yet these records of his must dovetail into, and be checked by, the accountant's figures. Thus the two sets of records are complementary; and to design an adequate system of cost-keeping requires a familiarity with the principles of accounting, plus a comprehensive knowledge of the engineering features of the particular task involved.

Factors of Expense.—All factors of cost will here be grouped and discussed under the following heads: (1) Labor; (2) Materials and Supplies; (3) Equipment; (4) Overhead Expenses.

Labor.—(By the term labor is here meant simply the direct or productive labor that can be clearly charged to one activity.) The fundamental records that pertain to labor costs are the time record and the pay-roll. The latter needs no particular comment here. The time-records should show not only the total time of work of each employee, but also the division of that time as desired, on different activities. As far as practicable, these records should be certified, either by the employee himself, as is feasible for an office force, or by foremen or time-keepers, in the case of laborers; for the signature adds materially to the reliability of the record. As to the relative value of foremen's and time-keepers' reports, opinion differs. Some writers argue that the former, with the certification of the foreman to the time-record of each man in his gang, are much more accurate and valuable than the report of a time-keeper who can be with that gang, at best, but a small part of the time. Other engineers, and more especially men of practical experience, point out that a field foreman, as a rule, cordially dislikes to putter with clerical work, and that both the report he is compelled to make out and his work of supervision are likely to suffer in consequence.

Again, the question arises as to the relative value of written time-reports, and those punched on prepared forms. The former are more flexible, require rather less explanation, are more easily erased. The latter are more uniformly clear and legible, should be more quickly made out, convey information in a more condensed form, provide an extremely simple means of duplication, and can be neither smudged nor fudged.

But whether time-cards or foremen's reports be adopted, whether the reports be written or punched on a printed form,—these are questions which must be decided

in every case upon consideration of the particular job and workmen involved.

Materials and Supplies.—These two terms are usually differentiated, the former being applied to raw material that becomes a part of a finished product, like cement, steel reinforcement, etc., the latter being used to designate auxiliaries necessary to carry on the work, which are used up in course of production, such as coal, oil, small tools, etc. These classes together form an element of the cost-keeping system that must be carefully considered. Inefficient handling and waste of material are usually responsible for a large share of excessive costs, and it is only by an efficient stores system that these wastes can be minimized, and the costs properly apportioned among the various activities. Such a system involves, besides the purchasing division of the office, one or more storekeepers, who care for this property, issue it to the field upon proper requisition, and receive receipts for all articles issued. At the end of the month these receipts are tallied with the inventory and "stores-received" accounts. The best form of inventory is some variation of the so-called "perpetual inventory"; by its use a record of the amount of each class of material at hand is always available, and the stock-taking need not be concentrated into a brief frantic interval, at the end of the year, but can be done gradually, an item at a time, the ledger or card-system being always posted for comparison. Such an inventory, to be sure, requires "perpetual" attention to keep it posted to date.

Some such system as the one outlined above is necessary in order to form a guide for purchasing, prevent undue wastes in handling, and provide for even an approximately accurate distribution of costs. Certain classes of material, of course, will go to the job in an entirely different and perhaps more direct way,—the sand for concrete dredged from a river-bottom, for instance. Their part in the cost-keeping system requires no special comment here; except that whatever manner of handling the materials be adopted, such records of quantities, labor, etc., should be so kept as to disclose any excessive waste or unnecessary expense.

Equipment.—This term includes all costs directly connected with units of plant, tools, etc., which have a more permanent status than the "materials and supplies" already considered. The proper care and preservation of such property is an important factor in minimizing costs, and the cost-records must consider the first cost, life, and usefulness of each important unit of equipment. The problem of allocating the equipment costs to the proper sub-divisions of a job is manifestly a complex one, in view of the distribution of the services performed by the plant. One solution often adopted is to charge each activity a (book) rental for the services of any unit of equipment, while employed in that capacity. This rental is an arbitrary rate based on the factors: first cost of the unit, interest on the investment, operating charges, maintenance and repairs, time lost through idleness, and depreciation.

Another method of handling equipment costs is to charge directly to work benefited such items of plant operation as can be fairly placed against it. For instance, if a dredge be placing fill in a cofferdam, the daily labor cost of operation, ordinary repairs, and the daily supplies of coal and oil, can fairly be charged directly to "cofferdam fill." On the other hand, such charges as those for more extensive repairs, and time lost through idleness, can hardly be distributed oftener than on a monthly basis; while the question of depreciation of plant, and interest on the investment, will probably be considered annually.

Of these two methods, the first seems to be generally preferable, in that it is on the whole simpler, and contributes immediately to give a total cost which is at least an approximation of the true total. The rental charge, to be sure, will never balance exactly with the true cost of the service, but must be revised from time to time, and the discrepancy adjusted.

Of the terms used above, the word "depreciation" requires some special comment; the application of all the others is sufficiently clear.

Depreciation is the lessening in value of any perishable property. The neglect to take into account this factor of cost, intangible though it is, leads to cost showings that are not justified by facts. The application of depreciation to certain engineering problems, such as the evaluation of the railroads, may raise difficult and complex questions. For the present purposes, however, it suffices merely to describe the most practical working means of accounting for the depreciation of equipment engaged in engineering work.

The Straight-Line Method.—This regards the total depreciation (first cost minus remaining value to end of probable life) as divided equally over that entire life period, so that the annual depreciation to be charged off is a constant. In applying this method, of course, the remaining value and probable life in each individual case, must be estimated with the help of any available data based on actual experience. This is the simplest and most general method of calculating depreciation for our purposes. A rough general rule recommended by some writers is: annual depreciation on machinery, 10 per cent.; on wooden buildings, 5 per cent.; on brick buildings, 3 per cent.; but such approximate generalizations have little value in this connection.

The Sinking Fund Method.—In this case it is assumed that a fixed annuity is to be set aside at interest to form a sinking fund, which, at the end of the probable life, will amount to the replacement value of the unit of plant. The depreciation at any time, then, being equal to the accumulated theoretical fund, will not increase uniformly, but slowly at first and more rapidly later than by the straight-line method. For certain purposes this method, which is based on the law of compound interest, is better adapted than the first.

Still other methods of treating this question have been devised. Their requirements are not necessary, however, for the simple case under consideration. What is wanted is a working formula, such as that furnished by the straight-line method. While annual depreciation has been referred to, implying a yearly consideration of this question only, it may be advisable to figure, or at least charge, the depreciation every month.

Overhead Expenses.—This term includes a great variety of indirect costs that are not covered in the foregoing classes. Chief among these are: supervision and miscellaneous labor costs; office expenses (rent, telephone and telegraph, etc.); heat, light and power; interest on investment; accident and fire insurance; taxes. The element of "plant," with its upkeep and depreciation, which is sometimes included under this general head, has already been discussed separately. The application of the cost-records to this class of expenditures is perhaps the most troublesome of all, so difficult is it to find an accurate method of prorating these charges. In general, it can be said that the distribution of costs should be made so that each activity will be charged in proportion as it has been benefited. But on just what basis the division is to be made,—whether in proportion to the total expenditure in each department, or in proportion to the direct labor costs, or by whatever other method,—all this must be decided upon consideration of the special circumstances in each particular case.

It is recognized that some of these factors of cost merely mentioned above, depreciation, interest on investment, etc.,—frequently have an important bearing on the larger aspects of the project considered as an investment. These, however, do not ordinarily lie within the province of the engineer in charge of construction, and are somewhat outside the scope of this article.

WHY HOUSE CONNECTIONS TO THE SEWER SHOULD BE CAREFULLY MADE.

SEVERAL years ago it was the general practice to use a sewer system to carry off any water or drainage which was objectionable to the property owners. For this reason roof leaders and cellar drains have been connected to the sewers, and according to C. G. Wigley, C.E., in "The Cornell Civil Engineer," most of the connections have been made with poor jointing material, or none at all, so that ground water would be admitted to the sewer system. This was all very well as long as the drainage or sewage could be discharged into the sewer system, and then required no further care or consideration. In those days the plumber, or contractor, was permitted great latitude in the method of laying the connections to the sewer, and also in the manner of making the joints in the sewer system, or house connections. The pipes used were sometimes of that class which to-day is known as seconds or culls. The joints were sometimes made with cloth wrapped about the pipe, with clay, or with inferior qualities of cement mortar, the method used depending largely upon the particular ideas of the person doing the work.

In those days the combined sewer system was the type in use as a general rule. The general idea was to discharge the sewage and drainage water from the surface of the ground, and certain portions of the sub-soil drainage into the sewer system in the least expensive and easiest manner. There were very few people who thought that these wastes after being discharged into the sewer system would ever require any further consideration. The old idea, which was fallacious in many respects, that a stream was self-purifying, was deeply rooted, and it required several years of nuisances on some streams before the limitations of the self-purifying actions of the stream were investigated and determined. At about the same time investigations showed that sewage-polluted streams were not safe sources of drinking water, even though the offensive odors and nuisances were not apparent at the point at which the water for human consumption was taken from the stream. These considerations, with others of equal importance, resulted in the enactment of laws in several of the more densely populated states, necessitating the construction of sewage disposal plants in order to properly dispose of the sewage.

This action led to a change in policy as to the methods of constructing sewer systems. Obviously a greater quantity of sewage required larger treatment works. Therefore, the separate, or sanitary sewer system, then came into greater use. In this system of sewerage it was intended that only the grossly offensive house sewage was to be received. No provision is made for roof drainage, surface drainage, and only a limited allowance for sub-soil drainage. It was soon found that it was not an easy matter to keep underground water from entering the sewers through leaky joints. The amount of water entering the sewers in this manner was so great, as in some cases to make the sewage disposal plant inoperative for several days after each heavy rain storm. This is a serious matter where the sewage plant is located above some water supply used by a neighboring city or town. Attempts have been made to prevent ground water from entering the sewer system by constructing underdrains, and by improving the methods of making the joints. The underdrains are often jointed tile covered with broken stone, or gravel, and laid alongside and below, or directly beneath the main sewer. These drains receive the ground water, and discharge it into nearby water-courses, or storm water conduits, and thus prevent the ground water from rising above the main sewer and thus entering leaky joints. The method is only partly successful.

In order to make the joints in better manner various materials of a compact and waterproof character have been tried. These compounds include mixtures of sulphur and sand; mixtures of tar and oil, with other ingredients, making a waterproof joint material, such as Jointite and G. K. Compound. These and some other compounds are poured while hot, thus materially increasing the cost of making the joints. The use of these compounds has in many cases reduced to a minimum the infiltration of ground water in the main sewers, and tests made on sewer systems, just completed, where such materials are used for jointing often give surprisingly low figures as to leakage per mile of sewer. These tests have been made before the house connections were laid. In several instances it was noticed that as soon as the house connections were made, the amount of ground water entering the sewers after a rain storm increased at an alarming rate. This leakage, or infiltration, in some cases was so great that the pumps and disposal works provided were entirely inadequate to properly care for the flow of sewage. At one place, for instance, the sewage treatment works provided were designed to care for a maximum wet-weather flow of 900,000 gallons per day. This figure included an allowance for probable ground water infiltration. Imagine, however, what the result must be when over 2,000,000 gallons of sewage and ground water is at times discharged at the disposal works. At another place the wet-weather flow is so great that the sewage after heavy storms flows out of the top of the manholes. At still another place the sewage was backed up into cellars and flowed out of the manholes into the streets because the unexpected volume of sewage was more than the sewage pumps could take care of. Investigations made at various places failed to show that any appreciable amount of this water came from roof leaders or surface drains secretly connected to the sewer system. In order to give some idea of the direct financial loss incurred by the admission of this ground water, the following instance is particularly mentioned: At one plant situated on a small inland stream, where the sewage from a population of about 6,000 persons is treated, the wet-weather conditions were so bad that it was considered advisable to institute some form of remedial measures in order to protect a large water supply, taken from the stream some distance below the town in question. The estimated cost of the necessary changes was $35,000, or $5.83 per person. This is a rather heavy tax.

The investigations mentioned above indicated that most of the leakage was due to the poor methods used in making the house connections. In one instance the contractor was found using clay for the jointing material on the house connection pipe line. In defense of the use of the material he stated that, "All the other connections in town were made in the same manner." The use of clay as a joint material was as early as 1878 discussed by a leading sanitary engineer, as follows: "The material most

commonly used for jointing pipes is clay, which is one of the worst materials that could be found for the purpose." There is no reason for any change in this opinion expressed so long ago. It was also reported to the investigators that joints on the house connections had been made with mud. This on inspection proved to be a very weak mortar made with a dirty sand of poor quality. Instead of the clean sharp sand called for in the town ordinance, a dirty loamy sand had been used. Instead of a mortar, consisting of one part cement and two parts sand, the mixture was about one part cement to six parts sand. It was found that in some cases in removing the caps from the Y-branches that the latter had been broken and then had been patched in very crude ways, so that large quantities of ground water were admitted to the sewers. In one town the wet-weather flow from leaky house connections was considerably reduced by requiring that in wet trenches the connections should be made with cast iron pipe with lead joints. It may be thought that a few leaky joints or a broken pipe on a house connection is not a serious matter, until a person realizes that the total length of the house connections is generally equal in length to the main sewer system, and in some cases even double the length of the main sewer. For example, if a main sewer has a connection every 25 feet, and each of these connections is 25 feet long from the main to the house, the total length of house connections is equal to the length of the sewer. Consequently, a few leaky joints on each sewer connection are in wet soils often capable of overloading the main sewer.

Some people believe that the admission of ground water into a sewer system is desirable. This belief is based upon the assumption that it is necessary to wash out the sewers, and provide a flow of water adequate to float the solid material. The benefits of this practice, however, are greatly overestimated, as a properly constructed sewer on a proper grade will cleanse itself, and if it is necessary to flush sewers laid on a low grade, it is better to rely on some means of flushing that can be readily controlled, such as the periodic flushing of the sewer with a fire hose, hand-operated flushing manholes, or automatic flush tanks.

Apparently the advisable methods of preventing the infiltration of ground water into the sewer system by way of the house connections is to improve upon the methods of making the joints, and also to improve upon the methods of placing the caps in the Y-branches. For the latter purpose disks of galvanized iron have been used, but would appear to be of little value, due to the rusting out of this type of cap in unused branches. The ordinary terra cotta caps may be held in place with a gasket of oakum, or jute, completely filling the space between the sides of the cap, and the bell of the Y, and a thin rim of cement placed over the oakum to hold the cap in place.

As to the methods of laying the pipe, some of the patented jointing compounds would be of great advantage when used with care, and by using pipe 3 feet in length only two-thirds as many joints would have to be made. The objections to some of the present methods of making house connections have been pointed out above, and the financial aspects of the situation have been briefly outlined, hoping that this subject will be discussed, and that rational methods for the prevention of this costly infiltration may be advanced.

In closing, it is desirable to indicate that there are certain sewer systems where the admission of certain portions of the ground water is permissible, but this privilege should only adhere to the combined system of sewerage, and even in this case the privilege should not be abused.

HIGHWAYS.

By W. Muir Edwards,

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IN the first article of this series the general principles governing the construction and maintenance of public roads was discussed, and a classification into Country Roads, Branch and Main Highways was suggested. The second article dealt with the first of these, and it is proposed in this article to consider Highways.

It is to be understood that the distinction made is between roads constructed of material in place and those whose roadbed, or at least the centre portion of it, is built up of material brought and placed therein. This improved centre portion varies in width from 10 to 24 feet, a width of from 12 to 16 feet being all that is required in most instances. The object of bringing in material and placing it on the natural soil is to make a hard, smooth surface upon which the rolling resistance will be small, due to its not yielding under the wheel loads. To accomplish this it is necessary that the natural soil, which must ultimately carry the load, be not exposed to too great an intensity of pressure. The filling material is compacted together and has more or less rigidity. The wheel loads cause a certain pressure over the surface of the road in contact with the rim, and this pressure is distributed by the filler to a much larger area of the soil supporting the roadbed. The principle is the same as that used in house foundation, bridge piers, etc.

The filling material is placed on the natural soil, which has been previously thoroughly compacted by rolling. This subgrade, as it is termed, may be either flat, requiring a greater depth of filling material at the centre to form the crown, or may conform to the shape of the finished surface, giving a uniform depth to the filling material throughout. The amount of material required depends upon the heaviness of the traffic and on the method of maintenance. There is a constant wearing away of even this hard roadbed, and this may be replaced either periodically or by continuous upkeep. In the former case the initial depth must be such that the improved surface will not wear too thin. This minimum allowable thickness depends on the traffic and the nature of the subgrade. The greater the depth, the larger is the area of subgrade over which any wheel load is distributed.

The filling material must be sufficiently hard to resist the crushing action of the loads and sufficiently tough to prevent its breaking under the continual blows to which it is subjected by the traffic. There should also be a binding together of the surface coat and of the body of the roadbed in order that water falling on the road shall not find its way down to soften the subgrade. The materials generally used are gravel and broken stone, but if neither of these is available any material which would satisfy the requirements might be used as a substitute. One of the functions of the alert highway engineer is to utilize local material, such as well-burned clinker, hard brick spalls, slag or other by-products, which may be economically used in the body of the roadbed, and thus save the expensive imported material for the wearing surface.

Pit-run gravel should not contain too great a proportion of sand or of clay if satisfactory results are to be obtained. About ten per cent. of clay or loam is

necessary to act as a filler and binder, but more than this is apt to wash to the surface and cause a muddy and dusty road. It is not possible to get as compact or waterproof a road with gravel as with stone, and hence it is more suitable for the lighter types of traffic.

There are two types of construction in broken stone roads, i.e., macadam and telford, named after the English highway engineers who first used them. The difference lies in the fact that in a macadam road the layers of small stone (up to ¾-inch in size) forming the filling material are laid directly on the subgrade, whilst in a telford road a layer of large stones is first laid on the subgrade and the smaller stones laid on these. Thus, when we speak of a macadamized road we mean one in which a 16-foot strip (more or less) in the centre is filled 6 in. to 8 in. deep with small, broken stones laid in layers on a rolled subgrade, each layer rolled and compacted, and the whole held together with the pulverized dust, which, when mixed with water, forms a cementary paste.

Not all stone is suitable for this purpose. Hardness, toughness and a cementary action on the part of the dust is necessary. It is possible, experimentally, to determine the characteristic of any proposed stone, and this should be done before any great outlay is undertaken. In fact, it might be safely said that a properly operated experimental department is an essential to any broad scheme of roadway improvement.

The comparative tractive efficiency of a hard road with a smooth surface and an unyielding roadbed is shown by the study of the following loads, which could be hauled at two and a half miles per hour on the level by a 3,000-pound team drawing an ordinary well-lubricated farm wagon with 2-inch tires: Brick pavement, eleven tons; asphalt pavement, six tons; macadam road, five tons; gravel road, four tons; ordinary earth road, two and a half tons; ordinary sand road, two tons. In using such comparisons in estimating purely financial benefits full loads only should be calculated, and the necessary cost in grade reduction and bridge construction to allow of heavier loads on the improved roadway must be allowed for. As has already been pointed out in the first article, the cost per ton mile to a farmer and a freighter are not the same, and deductions which apply to the latter cannot be used in their entirety in calculating the saving to the former. The ease, speed and frequency of intercommunication with neighbors and with local centres, which does so much to ameliorate agricultural conditions of life, should be kept prominently to the forefront when discussing road improvements.

The cost of both gravel and broken stone roads is comparatively large. Local conditions affect the cost materially, but for purposes of general comparison with earth roads it might be said that where material can be obtained locally the cost of a gravel road would be from $1,000 to $2,000 and the cost of a broken stone road $4,000 to $6,000 per mile. The cost of upkeep for a gravel road might be placed at $75 and for a broken stone road at $200 per mile per year. The problem which has to be faced in Alberta is that over the greater portion of the Province stone and gravel are conspicuous by their absence, and there would have to be a large additional cost to cover freight charges. Just to illustrate this, the cost for gravel alone at $1 per cubic yard for a road 16 feet wide, with a 1-foot depth of gravel, would be over $30,000 per mile. It would seem, therefore, that there exists an excellent opportunity for experimental work looking toward the utilization of other available material.

As has already been suggested in regard to earth roads, a judicious mixture of sand and clay might solve to some extent the difficulties met with in so many places where the material in place is either sand or clay, neither of which makes satisfactory roads. The clay expands with moisture, becomes very soft and plastic, and when dry contracts, leaving cracks in the roadbed. If rutted, the dried clay ridges are difficult to work down again into a smooth surface. Sand, on the other hand, expands and runs easily when dry and contracts when wet. A judicious mixture of the two would counteract the adverse tendencies of each, and so make a roadbed with a more permanently compact body which would withstand the action of the rain, be easier to work into proper shape when rutted, and possess a surface giving a better grip than does a clay road in wet weather.

In conclusion, it might be said that much remains to be done along the lines of improving existing earth roads and experimenting with mixtures of material locally available. A great improvement can be brought about by so simple a thing as systematic dragging. It will be some time before we are justified in seriously undertaking the construction of roads equivalent to the macadamized highways of older countries, where rock is more plentifully distributed than it is in Alberta.

MEASURING THE DISCHARGE THROUGH A VENTURI TUBE WITH A DIRECT READING METER.

A new method has been described by J. Dejust in Comptes Rendus, in which the usual apparatus for measuring the pressure difference between the full and the contracted sections of the tube and the integrating mechanism are replaced with an ordinary meter. The difference in pressure between the large and small sections of the tube causes a discharge between these two points.

The intake of the meter is directly connected to the full up-stream section of the tube; between the outlet and the down-stream contracted section of the tube a diaphragm is introduced. The algebraic expression of the ratio of the discharge through the tube to that through the by-pass containing the meter shows that this ratio is not constant. By adjusting the section of the by-pass tube and its diaphragm, however, the terms which are not constant can be reduced to a negligible value and the ratio made substantially constant for various rates of discharge. The constancy of this ratio has been tested on a line 100 mm. in diameter, provided with a Venturi tube having a contraction of 16 to 1, with a by-pass 20 mm. in diameter, a meter orifice of 12 mm., and a diaphragm calculated to make the ratio of meter discharge to flow through the line, 1 to 100. By varying the velocity in the line from 0.16 meter to 1.23 meters, the ratio varied from 103.82 to 105.53; that is to say, 1.65 per cent. of the smaller number. Reckoning from the mean of these two values, 104.675, the maximum error will be 0.82 per cent. of the true discharge.

Statistics show that since 1908 the increase in the use of creosoted wood block in the United States has been very rapid. For example, in 1908, 1,260,000 cubic feet are reported to have been laid, which amount was increased to a total of 10,000,000 cubic feet in 1911. Recent years have shown even greater increases, 1914 alone approximating 4,800,000 cubic feet of wood pavement.

CONCRETE HIGHWAYS SUBJECTED TO EXTREMES OF TEMPERATURE.

By H. S. Van Scoyoc, Assoc.M.Can.Soc.C.E.*

THIS paper is based on observations made by the writer in every province of Canada, except British Columbia. Pavements under construction have been observed, and in some cases have been inspected year after year with a knowledge of materials and methods used in their construction. Temperature ranges of 120° F. are not unusual and in some cases reach 150° F. In some sections below-zero weather occurs for several weeks at a time, so that the depth of frost is greater than in most parts of the United States. The effects of these conditions on concrete roadways can be discussed in three groups:

(1) A breaking up of the surface due to mechanical frost action.

(2) Expansion and contraction due to temperature changes with the formation of transverse cracks.

(3) The upheaval of slabs or parts of slabs with the likelihood of longitudinal cracks occurring.

Mechanical Frost Action.—While it is possible that a porous concrete, weak in cement, might tend to break up on account of expansion caused by freezing, there is small likelihood of this trouble occurring if a satisfactory quality of concrete is secured. No actual case of this kind has ever come to the writer's attention. This must not be confused with the damage that results when concrete is laid in freezing weather or is frozen before it has had sufficient time to set up properly. This is a real danger and is one difficult to remedy after it has taken place. In addition to rutting or picking up under traffic concrete roadways laid in freezing weather may lack sufficient strength to withstand the stresses that the succeeding winter and spring induce.

Expansion and Contraction Due to Temperature Changes.—The first thought with regard to the effect of such ranges of temperature on expansion and contraction is that it would prove serious. When it is realized, however, that most paving is laid at a temperature of at least 60° F. and that the thermometer will rarely rise above 90° F., the amount of expansion to be provided for on account of temperature change is not large.

The drop in temperature in winter produces a contraction which to a considerable extent provides for expansion during the hot weather. Contraction is very evident during Canadian winters. In 1914, the Canada Cement Company, Limited, laid a concrete road about one-half mile in length at their Point Aux Trembles plant, near Montreal. It was constructed to serve as an outlet for heavy traffic from the plant, but was to some extent an experimental road. About 1,000 feet was one-course work reinforced, a second thousand feet was two-course work reinforced, and the remaining section was standard one-course work without reinforcing. Hydrated lime equal to 10 per cent. of the cement by weight was added to about one-half of each section. In both of the reinforced sections an attempt was made to have the work continuous, special care being taken to have the new concrete bond with the work of the preceding day, the reinforcing in all cases overlapping. For several weeks after the concrete was laid the weather was quite warm and apparently all of the sections had bonded, for no transverse cracks were noticeable, although a close watch was kept from day to day. A sudden change in temperature, of about 50°, occurred, and over night a noticeable transverse crack appeared between successive days' work except in one instance where less than 50 feet of concrete had been laid during a day owing to a mixer break-down. During the winter some of these joints opened to a width of more than half an inch. Other instances could be cited showing very noticeable contraction. At present the writer cannot recall a single instance, however, where there has been creeping of one slab on the other or evidences of buckling where transverse joints ¼ inch wide have been provided at intervals not greater than 35 feet and have been properly maintained.

It is during the winter and very early spring that the contraction is most marked, and there does not seem to be the lag due to moisture change that has been reported from localities further south.

While some transverse cracks are undoubtedly due to improper filling over pipe or box culverts, the writer believes that many of them represent carelessness in stopping work other than at a vertical joint.

Heaving.—Concrete pavements in Canada have shown evidences of heaving. During the winter of 1913 a street at Steelton, Ont., adjoining the Canadian "Soo," was raised by frost two inches from actual levels taken by the town engineer. It returned to place with no damage except a longitudinal crack. In a street in Truro, N.S., laid in 1913, one slab raised about two inches, as was shown by its elevation above the combined curb and gutter adjoining. It settled back into place in the spring without even developing a crack.

Station Street, Oakville, was paved in 1914. In a length of about a mile there is only one spot where cracks have developed and there is known to have been an underground spring there that was not properly taken care of.

This work is reinforced and the crack has not opened to any noticeable extent. It has been given no repairs to date.

An exceptional spell of warm weather in January of this year took all of the frost out of the ground along the Toronto and Hamilton highway. The completed portion, about 17 miles in length, was carefully inspected. In only one spot had longitudinal cracks developed, and there only three slabs were affected. At this particular spot the side ditches were not taken down to their full depth until after the concrete had been laid. In digging the ditches, quicksand was encountered and it is now very evident that when the thaw saturated the ground there was a lateral movement of the subgrade material into the open ditch on the north side of the road, leaving the slab on that side unsupported. It settled and a longitudinal crack developed. The slab is noticeably lower on the north side of the crack than it is on the south side.

During the summers of 1911 and 1912 there was laid near Winnipeg, Man., several miles of what has sometimes been spoken of as a concrete road. It was actually constructed as a base for an asphalt pavement, but in an endeavor to reduce the initial cost it was not covered. The mixture was about 1:3:6, and no transverse joints were made. It was laid on the natural soil, gumbo, a very retentive clay, and was given only the attention that subbase work usually gets. It developed transverse cracks approximately every 30 feet, and during the first winter developed a number of narrow longitudinal cracks. It received no maintenance. The second winter opened up the longitudinal joints until many of them were more than an inch wide. By another spring some of them looked like gullies.

Less than a mile from this location there was laid in 1913 a road under much more satisfactory conditions,

*Chief Engineer, the Toronto and Hamilton Highway Commission.

although it also was laid on the natural soil and the drainage provided was field tile placed only about 10 inches below the surface. This road went through the first winter with only about eight cracks in a length of 2¼ miles. The second winter, however, largely on account of defects in the drainage, developed a much larger number of cracks, although the road is still in a satisfactory condition.

In the late summer of 1912 a portion of the King Edward highway, passing through the village of Napierville, Que., was laid of concrete, being more or less an experiment by the Department of Roads of the province. The grading was carefully done by day labor by the Department of Roads and was thoroughly rolled. The concrete work was carefully done by a conscientious contractor with many years' experience in concrete work. This road has passed through four winters. Four cracks have developed. They have been filled once each season and the road is as good as when built, although it gets all the through traffic from Montreal to New York State, as well as the local traffic of the village.

Other instances could be given of longitudinal cracks developing, but enough has been said to show that in some cases the trouble has been caused by settlement of the sub-grade near the edges of the concrete, due to improper preparation of the sub-grade. Sometimes boggy spots beneath the concrete have not been properly drained; the system of drainage provided has not permanently kept the sub-grade dry. In practically every case mentioned there is sufficient evidence to show that lack of proper care rather than climatic conditions has led to cracks. Reinforcing has had a beneficial result in some cases at least, by adding sufficient tensile strength to avoid the formation of cracks.

Canadian weather does not prevent the building of successful concrete roads, but it does serve to emphasize the advisability of thorough drainage, the careful carrying out of proven methods of construction and the absolute necessity for a maintenance system that takes care of defects when they appear.

A great irrigation system in India was opened officially in December. It comprises three separate but connected canals—the Upper Jhelum, the Upper Chenab and the Lower Bari Doab. These aggregate 322 miles in length, with about 22,645 miles of auxiliary channels and laterals. They provide for the irrigation of about 2,200,000 acres of arid land in the Punjab province, in the northern portion of the country. As described in a paper presented before the Institution of Civil Engineers by Sir John Benton, the eastern portion of the Punjab had a tract of 1,500,000 acres of arid but good land which could not be irrigated from any water supply near at hand, owing to previous utilization and reservation of such supply. On the western side of the province the Jhelum River provided a large and unused amount of water. To deliver it to the arid lands necessitated extensive and difficult works, with the crossing of two large rivers and numerous mountain streams and torrents. Bridges are spaced at average intervals of 1.6, 1.5 and 3.4 miles for the three canals respectively. The regulating works, etc., are largely of brick. Chambers in the floors provide settling basins for the silt and so reduce erosion of the masonry floor. Inspectors' houses are placed at intervals of about 10 miles. There is a complete telegraph system. Flour mills have been located at some of the falls on the canals. The project has been carried out by the provincial government of the Punjab at a cost of about $35,000,000.

COAST TO COAST

Calgary, Alta.—The new concrete pier under the Ogden bridge has been completed.

Toronto, Ont.—The new main sewer on Dundas Street, between Humberside Avenue and Runnymede Road, has been completed.

Brantford, Ont.—Freight services on the Lake Erie & Northern Railway between Brantford and Galt was opened on March 1st, giving Brantford connection with the main line of the C.P.R. at Galt.

Spirit River, Alta.—The Gurney Scale Company, of Hamilton, Ont., recently shipped a 6-ton dump scale to this place. This will be the furthest north in Canada that a dump scale has ever been operated.

Victoria, B.C.—The E. & N. Railway Company has been given until April 10th to sign the agreement respecting the proposed Johnson Street bridge, otherwise no further negotiations will be carried on with it.

Vancouver, B.C.—An arrangement has been made for the Dominion Government to pay the province more than the latter's $300,000 for the Kitsilano Reserve and to hand it over to the harbor board to develop as an industrial centre.

Sarnia, Ont.—At a meeting held to discuss whether it would be advisable to use 25-cycle power from the Hydro or maintain the present 60-cycle plant, it was shown by the Hydro engineer that the former was much cheaper for power purposes.

Ottawa, Ont.—A deputation from the Trent Valley was given encouragement in its application for hydro power for eastern Ontario. The obstacle at present lies in disputed jurisdiction of the provincial and federal governments over water powers.

Ottawa, Ont.—It was announced during the budget debate that a new process for refining nickel had been discovered in Canada by which 100 lbs. of matte could be converted into 50 lbs. of metal in 48 hours. The process will be applicable to low-grade as well as high-grade ores.

Victoria, B.C.—The contract for the Canadian Northern Pacific Railway Company's bridge over the upper arm of the harbor has been let and plans are under way for the permanent bascule span which will provide for a clear opening of 70 ft. for purposes of navigation.

Toronto, Ont.—The Ontario Legislature will approve the plans of the engineers of the Hydro-Electric Power Commission of Ontario for a large power development in the Niagara Peninsula. It is said the immediate development will be 100,000 h.p., and there are visions of an ultimate capacity of 900,000 h.p.

Vancouver, B.C.—It is expected that arrangements will be completed shortly whereby the Canadian Northern Railway will purchase right-of-way along the Fraser River, which will enable it to link up its main line with steel already laid on Lulu Island, extending to the proposed permanent ferry terminus at Woodward's Landing.

Moose Jaw, Sask.—The Canadian Pacific Railway has installed a pumping unit at the high-pressure reservoir. This, in conjunction with the advent of milder weather, has relieved the water situation considerably. More water each day is being secured from Caron, and if the warm weather continues the flow will soon commence to approach normal.

Editorial

SELECTION OF ENGINEER OFFICERS.

At the last annual meeting of the Canadian Society of Civil Engineers, a resolution was framed offering to cooperate with the Dominion Government in the training of competent officers for the engineering branches of the service. The resolution also tried to impress upon the government the importance of requiring that all engineer officers should have had practical engineering training before receiving commissions. This resolution was duly forwarded to Sir Robert Borden and Sir Sam Hughes.

The Council of the Society has not as yet made public the replies that it received, but it is unofficially understood that the replies were of a most unsatisfactory character. If this is true, it is most unfortunate. The Canadian Society of Civil Engineers is in the best possible position to assist the government, not only in the training of engineer officers, but, what is more important still, in the selection of those officers. The military authorities cannot be so well posted regarding the engineering ability of the various applicants, as are the members of Council and the branch executives of the Canadian Society.

The Canadian authorities would be well advised were they to follow the lead of the British authorities in this regard. In England no person is admitted to the Royal Engineers except on certification by the president of the Institution of Civil Engineers. An inspection of the form that must be used by all who apply in England for appointment to a commission in the regular army during the war, shows that a candidate for a cavalry regiment must apply to the officer commanding a cavalry regiment; that a candidate for an infantry regiment must apply to the officer commanding a service battalion or a battalion of the special reserve; that a candidate for the Royal Artillery or for the Army Service Corps must apply to the War Office; and that *a candidate for the Royal Engineers must apply to the president of the Institution of Civil Engineers.*

CIVIC IMPROVEMENT LEAGUE.

Every opportunity offers to the Civic Improvement League to do noteworthy work. If political patronage and personal glorification are not allowed to dictate the actions of this body, some real good can be expected to result from their efforts. We suppose it is only natural that in launching any national movement of this sort, some persons must be included in the organization who have little or no contribution to make excepting nice-sounding speeches.

It will be unfortunate, however, if too many politicians and self-seekers are permitted to mould the affairs of the League. The chairman of the Dominion Council of the League undoubtedly has borne this in mind, however, because the list of provincial and national representatives that he has named appears to be more free from this sort of thing than one might expect.

It is worthy of comment, however, that among the list, as published in the daily newspapers, there does not appear the name of any representative of any engineering organization. One could reasonably suppose that the Canadian Society of Civil Engineers would be represented very strongly in this movement. Engineers should take, and should be permitted to take, not only a large part but the largest part in this movement, because, by their training, engineers are most fitted to deal with questions of civic improvement. And as a matter of fact, even among the engineers, the only ones who are fully competent of doing any real work in this regard are those who have been specially trained in the department in question.

LETTER TO THE EDITOR.

Re "An Interesting Point in Retaining Wall Design."

Sir,—Referring to Mr. E. M. Proctor's letter, which appeared in your issue of February 17th, entitled "An Interesting Point in Retaining Wall Design," I beg to submit the following reply to his enquiries:—

The analysis in Case No. 1 is correct, providing the tension in the back of the wall is taken care of by reinforcing rods. This condition could also exist without the presence of the reinforcing rods, provided the tensile value of the concrete is sufficient to take care of the tensile stress and is not destroyed by the development of cracks.

The analysis in Case No. 2 is correct, providing the tensile value of the concrete is zero and reinforcing rods are omitted. This condition will occur when no reinforcing steel is used and cracks have developed in the back of the wall, thus destroying the tensile value of the concrete. The appearance of cracks in the back of a wall, which is almost sure to be the result if Case No. 2 is used, is exceedingly undesirable and also detrimental to the safety of the wall.

The analysis in Case No. 3 is not correct, as the wall cannot be assumed as a beam under simple bending, because we have in this case both simple bending and direct stress in the section of wall under consideration. The formulae $fc = \frac{M}{\frac{1}{2} k j b d}$ is applicable only to reinforced concrete beams under simple bending and therefore cannot be applied in the above case.

R. L. HEARN.

Toronto, February 25th, 1916.

CIVIL SERVICE COMMISSION OF CANADA.

The Civil Service Commissioners announce that applications for two technical clerkships for temporary employment in the topographical branch of the Department of the Interior will be considered from graduates in Applied Science or honor mathematics of some recognized university or those who have passed the final examination for Dominion Land Surveyor or an equivalent examination. Salary will be at the rate of $100 a month and application forms must be filed in the office of the Civil Service Commission, Ottawa, by the 20th of March. Application forms may be obtained by addressing the Secretary of the Commission at Ottawa.

PERSONAL.

D. H. McDOUGALL, Mem.Can.Soc.C.E., has been appointed general manager of the Dominion Steel Corporation.

Capt. F. D. BURPEE, superintendent of the Ottawa Electric Railway, will be major of the 207th Battalion recently authorized to be recruited in Ottawa.

Lieut. R. M. CALVIN, 5th Field Company, Canadian Engineers, has been slightly wounded in a recent engagement in France. Lieut. Calvin is a recent Science graduate from Queen's.

F. W. THOROLD, of Toronto, W. S. LEA, of Montreal, and F. A. DALLYN, engineer of the Ontario Board of Health, have been appointed to report on the Sarnia waterworks.

JOHN COLLINS has been appointed general manager of the Canadian Steam Boiler Equipment Company, Toronto. Mr. Collins was formerly supervising engineer with Gillespie Bros., Toronto.

BERTRAM W. SETON has temporarily severed his connection with the Dominion Engineering and Inspection Company in order to take charge of the adjustment department of the Imperial Munitions Board.

FORREST & LIGHTFOOT have opened an office in Quebec City as engineers and contractors. Both members of the firm have been connected with the National Transcontinental in the construction of shops at Transcona and Quebec.

ALEXANDER C. HUMPHREYS, president of the Stevens Institute of Technology at Hoboken, N.J., and one of the leading engineers of the United States, was the speaker at a Canadian Club luncheon held in the Chateau Laurier, Ottawa, recently.

E. P. ROBERTS, consulting engineer, of Cleveland, Ohio, called at *The Canadian Engineer* office last week on his way to the Cobalt District to report on a water power project which United States capitalists may finance. Mr. Roberts is a past president of the Cleveland Engineering Society and has in the past reported on several other Canadian water power schemes.

FRANK G. WALLACE, of Pittsburgh, Pa., for many years a director of the Canadian Locomotive Company, has accepted the position of managing director of the company, and WILLIAM CASEY, who has held the position of assistant general manager, has been promoted to be manager. The resignation of A. W. WHEATLEY as general manager was announced recently.

CHAS. J. MURPHY, B.A.Sc., A.M.Can.Soc.C.E., who for the past five or six years has been chief engineer of the Crow's Nest Pass Coal Co., The Morrissey, Fernie & Michel Railway, and the Crow's Nest Pass Electric Light & Power Co., has decided to enter private practice, and has opened an office as a consulting engineer, in the Nova Scotia Bank Building, St. Catharines, Ont. Mr. Murphy is an S.P.S. graduate. Previous to going west, he was on the metallurgical staff of the Canadian Copper Company.

The Panama Canal dredging fleet has established a new record for 24 hours, having taken 57,300 cubic yards of earth out of the Gaillard Cut in that time.

The previous high mark was less than 45,000 cubic yards. Of the amount taken out in the record achievement the dredge "Cascadas" alone removed 23,500 cubic yards. The prior record for a dredge was held by the "Paraiso," with 18,000 cubic yards.

OBITUARY.

WILLIAM A. LAVIN, a well-known contractor of Moose Jaw, Sask., was killed a few days ago in an automobile accident at Long Beach, Cal.

WALTER R. LEAVENS passed away at his home in Hallowell Township, Ont., recently, at the age of 59. He had been road surveyor for the township of Hallowell for many years, and had superintended the construction of most of the bridges in that district.

G. G. SHELDON WILLIAMS, of Victoria, B.C., who for 17 years was editor of the British Columbia Mining Exchange and Engineering News, died recently. He was a member of the Canadian Mining Institute and did a great deal of wark in connection with circulating information about British Columbia's mineral wealth.

STEVENSON LAMBE, consulting engineer of New York, died recently. Mr. Lambe, who was in his 79th year, has held many important posts. In 1857 he was appointed city surveyor of New York; later he became chief engineer of sewers. He also planned and built New York's first cable road in 1883. As consulting engineer for the department of works he introduced a system of improved street pavements, which is in extensive use throughout the United States. In 1897 he was appointed consulting engineer of sewerage in connection with the rapid transit tunnel. Mr. Lambe was one of the original members of the American Society of Civil Engineers, having been elected in 1868.

VICTORIA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the meeting of the branch held on February 22nd a very interesting lecture on "Modern Bridge Architecture" was given by C. E. Fowler, C.E., of Seattle. Mr. Fowler discussed bridges in a non-technical manner, going into the history of bridge building, as well as fully describing modern types of bridges. His address was well illustrated with photographic slides.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Calgary branch recently gave a dinner in honor of C. D. Howe, chief engineer of the Dominion Government Grain Commission. Following the dinner, Mr. Howe gave an address on the construction and purposes of government internal storage elevators, illustrating it with views of the elevators, particularly of the Calgary one.

At a meeting of the branch held on February 24th, an innovation in the way of a "ladies' night" was tried, and all present agreed that it was a success.

After the dinner, Dr. J. G. Rutherford, superintendent of agriculture and animal industry, C.P.R., Department of Natural Resources, addressed the meeting. Dr. Rutherford chose "Some Thoughts on the Present World Situation" as his subject. He stated that the world, as we know it, is barely one hundred years old by reason of the remarkable development that has taken place in the last hundred years.

L. K. Comstock and Company, contracting engineers, have opened their Canadian offices in Room No. [illegible] New Birks Building, Montreal, with Douglas Milligan Company in charge as their representatives.

Volume 30. Toronto, March 16, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

UNIQUE CHIMNEY CONSTRUCTION

A DESCRIPTION OF THE MONNOYER SYSTEM OF REINFORCED CONCRETE CHIMNEY CONSTRUCTION, WITH SOME DETAILS OF CONSTRUCTION CONCERNING THE FIRST EXAMPLE TO BE ERECTED IN THE DOMINION OF CANADA.

By C. V. JOHNSON, A.M.Can.Soc.C.E.
Engineer for Jos. Gosselin, Contracting-Engineer.

OF recent years an agitation has been on foot with a view to the improvement of factory and machine shop buildings from an architectural standpoint. Much time and money has been spent in preparing plans of buildings which would combine the desired utility with a pleasing harmony of appearance. This to escape the end, which has too often been the result of a lack of artistic sense in design, of these structures becoming a blot on the landscape. Time and money thus spent is well repaid in the results obtained, and no doubt many proprietors have already come to realize this. It may be argued that an artistically designed factory building will not bring any larger return for its output than one of similar capacity but less pleasing exterior. Nevertheless, it would appear that there must be an advertising value in the impression conveyed on the public mind by the appearance of the place in which the products are prepared for use: such an impression being undoubtedly a factor in influencing the selection of the article desired.

Any large manufacturer will spend considerable sums on advertisements designed to please the consumer, and what more efficient advertisement can there be than an artistically beautiful structure with harmonious surroundings?

Fig. 1.—Blocks Ready for Use.

Fig. 2.—Laying the Blocks.

Considering the question again from a larger aspect, not only is there a benefit to be obtained by the community from the prosperity of its individuals, but the appearance of the structures by which it is surrounded undoubtedly plays a large part in its value to the country at large.

Admitting, then, the value of appearances, it remains for us to consider the question of means; and when these means are placed at our disposal without having to resort to an increase of expenditure, it behoves us to take advantage of them. It is one of the purposes of this article to show that these objects may be attained, at least in the case of a structure which is, in almost every city and town, one of the most prominent features; that is to say, the inevitable tall chimney, which is almost sure to obtrude itself on the eye at every turn.

So often is the aesthetic sense offended by the sight of an ungainly, though mathematically correct, monstrosity, towering high above the surroundings, with apparently no regard for anything but its utility as a means of polluting the atmosphere with dense clouds of smoke and gases. True, in many instances proprietors have risen above the consideration of mere dollars and cents, and succeeded in erecting chimneys which combine both utility and a fairly pleasing appearance. These chimneys are

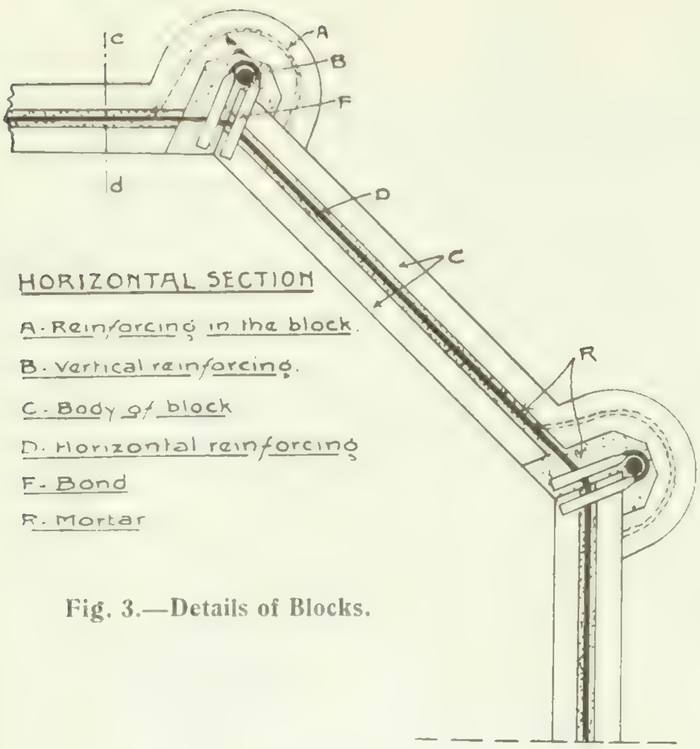
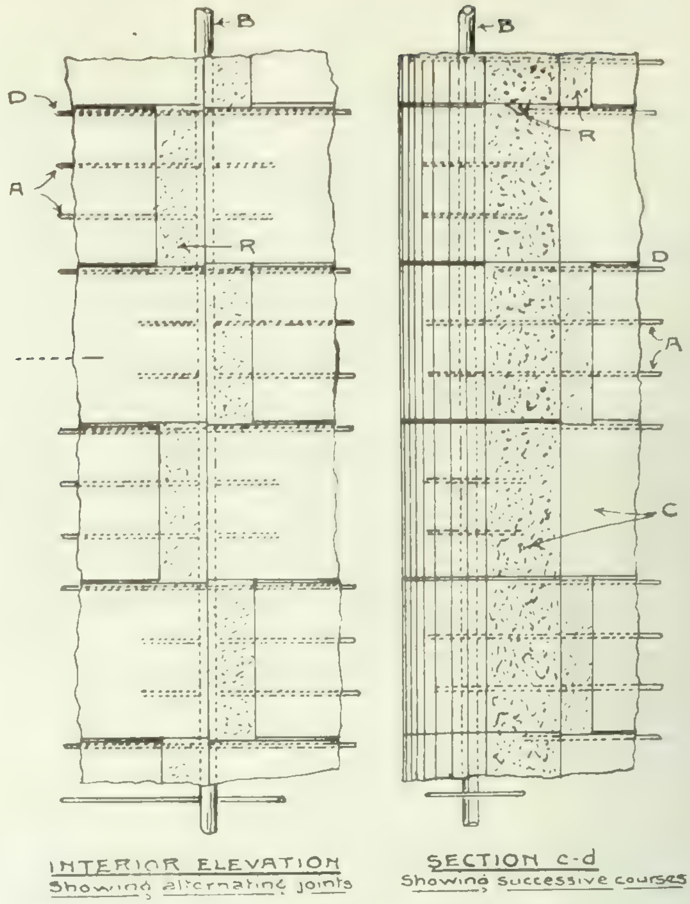


Fig. 3.—Details of Blocks.



generally of brick construction, brick having, until recently, lent itself more readily to the attainment of this object than either steel or concrete. But, on the other hand, in so many cases the question of expense has acted as a deterrent, and resulted in the erection of a structure which is anything but pleasing to the eye.

The difficulty, then, has resolved itself into a question of combining architectural beauty with economy of construction. The economic advantages of reinforced concrete are indisputable, this having been recognized some years since by our neighbors across the line, with whom

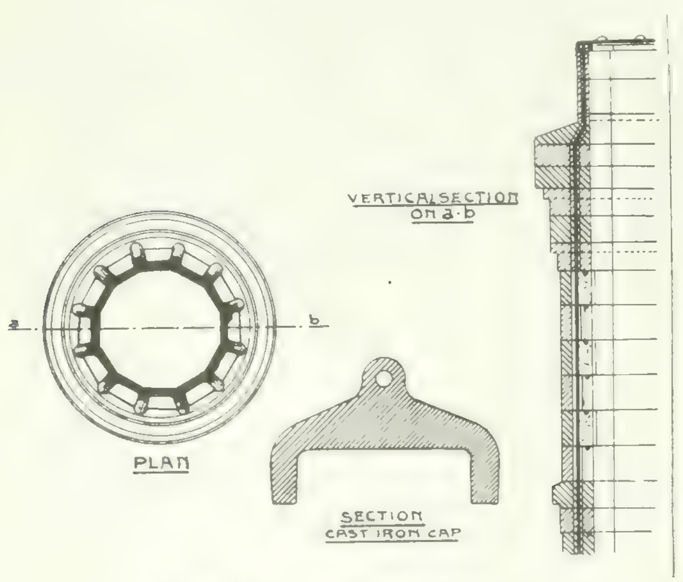


Fig. 4.—Details of Chimney.

rests the credit of first carrying out chimney constructions by means of reinforced concrete. The system first adopted was a chimney of cylindrical form, consisting of two distinct shafts separated by an air space of from three to four inches. This design was generally used until the year 1909, when the conical chimney was adopted as being more stable, less costly, and of better appearance. It was,

Fig. 5.—Foundation Reinforcing.

however, some years before this—to be exact, in the year 1906—that our Belgian confreres had evolved a reinforced concrete chimney construction which combined stability, and economy and rapidity of construction with an artistic appearance unequalled by any other design.

In 1914 the first chimney of this type to be erected in Canada was constructed for the National Transcontinental Railway shop plant at Quebec. Of this chimney a more detailed description will follow.

General Construction.—For a general description of the Monnoyer chimney a translation of the information imparted by the Belgian engineers themselves will be given. On general lines it is as follows:—

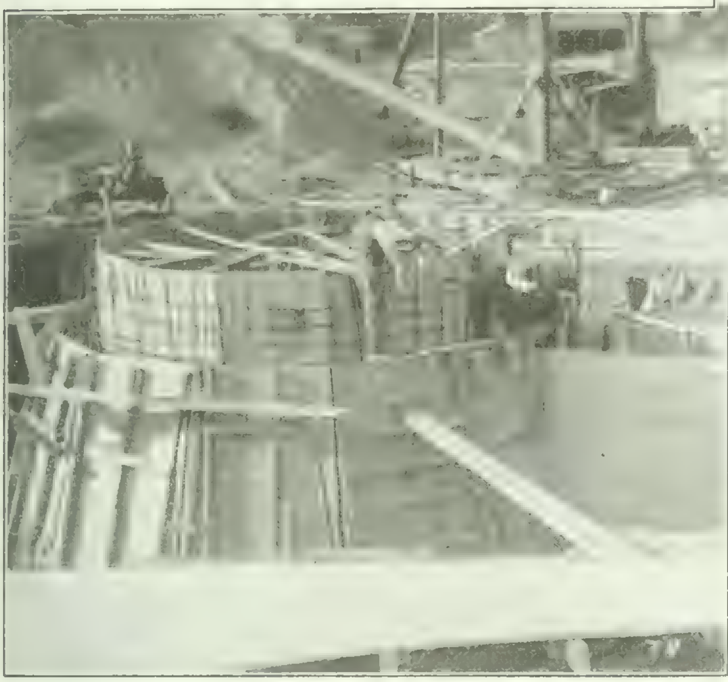


Fig. 6.—Forms for Foundations.

"The basic principles of the construction is, in the larger aspects, similar to other designs; that is to say that they are composed of a foundation, a base, and a shaft, all of which are of reinforced concrete.

"The foundations and footings being constructed at, or in the vicinity of, the ground level, do not present any unusual problem, but it is the shaft itself wherein rests the niceties of construction.

"The shaft is constructed of blocks 10 ins. in height for the current diameters. These blocks, which vary in number in accordance with the diameter of the chimney, constitute by their assemblage a course which is then 10 ins. high. Each one of them is formed with a hollow projection or hook at one end (Fig. 1), which is set immediately over the corresponding projection on the block below. These projections constitute also the vertical ribs of the chimney, and it is in these ribs that the vertical reinforcing bars are placed (Fig. 2). The reinforcing bars are carried up continuously by means of joints the full height of the chimney, and are at the same time firmly anchored in the foundations.

"The blocks themselves, which may be constructed in a work-shop or any convenient place, are reinforced with steel rods to make them capable of enduring the strain of transportation and placing. Each block has in its upper surface a groove, in which is lodged the horizontal reinforcing rod, forming a bond sunk in the joint.

Fig. 7.—Foundations with Forms Removed.

"The square end of the block is set in the head of the block adjoining; that is to say, the portion which constitutes the rib; and as this method of placing allows of considerable latitude in the setting of the blocks, it permits a variation in the diameter of each course, thus obtaining the conical shape so indispensable to a favorable appearance.

"The operation of erecting is effected very rapidly; masons working in the interior of the chimney, receive their blocks ready to lay, put them in place, mortar the 10 inches in the interior of the rib, prepare the joints for the new blocks, and continue very rapidly to lay them.

"The chimneys are, in general, terminated at their summits by one or two bands of specially constructed blocks, and a cast iron coping."

Fig. 8.—Backfilling Around Foundations with Hayward Bucket.

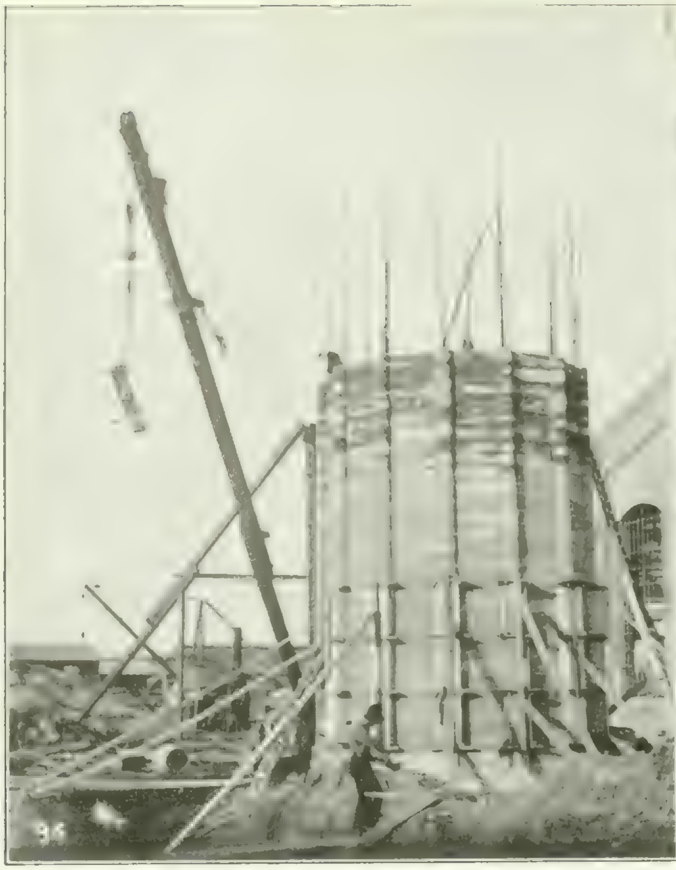


Fig. 9.—Placing Blocks with Derricks.

Fig. 10.—Tamping Concrete in the Forms.

The Canadian Example.—The chimney constructed at Quebec for the locomotive shop plant of the National Transcontinental Railway is 200 feet in height above the ground level. The inside diameter at the summit is 9 ft., and at the base 14 ft. The foundations were carried down to solid rock, which was encountered 19 ft. below the surface. The smoke flue, which opens into the chimney below the ground level, is 11 ft. 5 ins. high by 5 ft. 6 ins. wide inside, and is constructed of reinforced concrete.

The vertical reinforcing rods in the foundations were carried into the footing almost to the base, and continued to the top of the foundation, overlapping and bonding those of the superstructure for a length of from four to five feet.

In constructing the foundation the footing was first poured for a depth of one foot, then the vertical rods were set and held in place by means of wood framing, as shown in Fig. 5. After these rods were placed the balance of the footing, about 3 ft., was poured, and allowed to set. The framing was then removed from the rods, and the forms for the balance of the foundation constructed (Fig. 6). The concrete in the footings was poured by means of a derrick and a bottom-dumping bucket; but for the upper portion it was found more convenient to use barrows, owing to the limited space between the forms, and the quantity of steel which had to be held in place during the work. Before reaching the top of the foundation the reinforcing rods for the superstructure were placed and the concrete poured around them. The concrete was then allowed to set and the forms removed before commencing to lay the blocks. An illustration of the foundation ready to receive the blocks is shown in Fig. 7; and the backfilling of the earth around it with a Hayward orange peel bucket in Fig. 8.

In the meantime the making of the blocks was proceeding in an adjoining shed, so that by the time the foundation was completed there were sufficient blocks on hand to keep the erection going continuously.

The blocks were made in four collapsible forms, these being so constructed that they served equally for all blocks from 4 ins. to 9 ins. in thickness, and any length desired. The labor employed consisted of two masons and three helpers, the concrete being mixed in a small gasoline-driven mixer. The concrete, which consisted of a 1 : 2 : 4 mixture, was placed in the forms in a semi-dry state, the reinforcing rods inserted, and the whole well tamped (see Fig. 10). Immediately upon the completion of a block it was removed from the form and placed to one side, to be sprinkled daily for a period of about two weeks or until ready for laying. It is perhaps needless to state that the forms were well cleaned and soaped after each operation. The whole operation of making the blocks, 3,290 in all, occupied 82 working days, or an average of approximately 40 blocks per day.

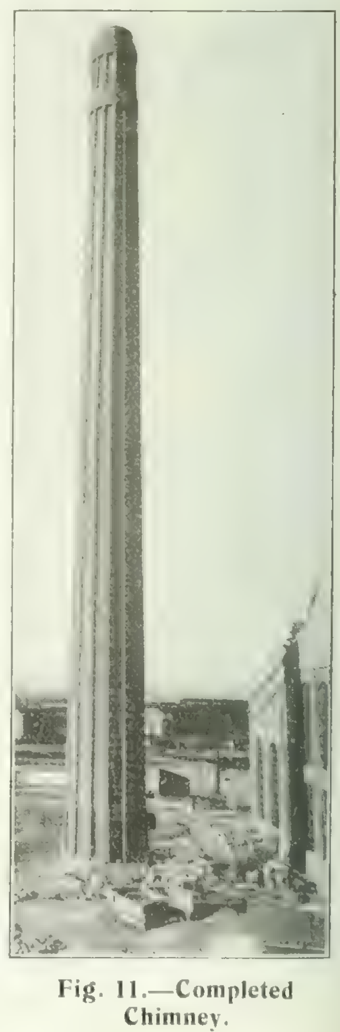


Fig. 11.—Completed Chimney.

On September 16, 1914, the first blocks were laid

on the foundations, and the chimney completed on December 10th following. The construction could have been carried on much more rapidly, but as there was no particular hurry the men worked only in fine weather, and occupied themselves in bad weather making blocks under shelter. The labor employed in erecting the chimney consisted of two masons and five helpers. With this force it is possible to lay six courses of fourteen blocks each in one day.

In the erection the blocks were at first hoisted into place by means of a steam-driven derrick (Fig. 9), and the mortar hauled up in buckets with a rope. When the chimney had attained too great a height for the derrick a hoist was installed on a platform in the interior, and a gasoline engine placed at the end of the smoke tunnel in the power house. By this method the blocks and mortar were hoisted up inside the chimney, and the construction continued thus until the finish. Fig. 11 is a view of the completed chimney taken in the summer following its erection.

For the mortar forming the bonds between the blocks a mixture of one of cement to two of sand was used. The chimney was lined inside with 4 ins. of firebrick set in fireclay, to a height of 50 ft. above the top of the smoke flue. A sectional steel ladder was built up along with the erection of the chimney, the supports being tied into the vertical reinforcing rods. The whole was surmounted with a cast iron cap, similar to that shown in Fig. 4, into which was set the lightning rod.

The design for the shaft of the chimney was prepared in Paris, France, by the engineers of the Monnoyer Company. The foundations were designed by, and constructed under the supervision of, the engineers of the general contractor, Jos. Gosselin, of Quebec and Levis. The subcontractor for the erection of the superstructure was the firm of Ed. Pelletier & Fils, of Quebec, which firm holds the patent rights for this system in Canada and the United States.

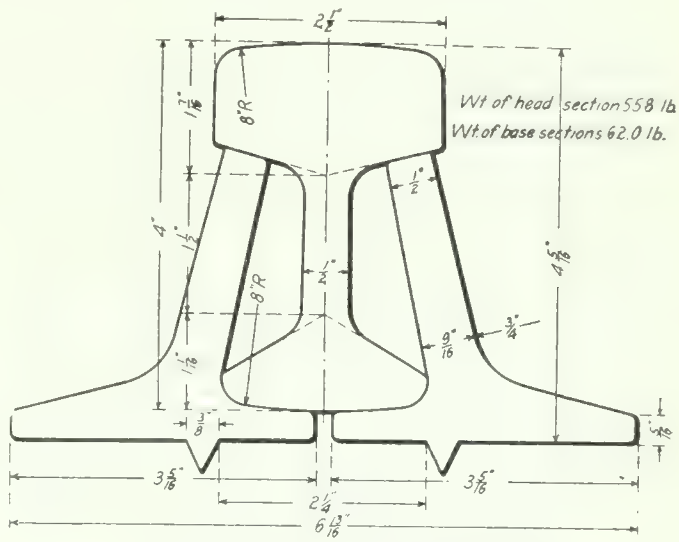
In conclusion it might be stated that this system of reinforced concrete is also successfully used in the construction of water tanks, condensers, and dust towers, many beautiful examples of which may be seen in the various countries of Europe.

The offices of the Mexican Petroleum Company, the Huasteca Petroleum Company, the Petroleum Transport Company and the Caloric Company have been moved from 52 Broadway to 120 Broadway, New York City.

The estimated value of the forest products of Canada in 1914 was $176,672,000, as compared with $177,120,000 in 1913, $182,300,000 in 1912, and $170,600,000 in 1911. The total of $176,672,000, representing the value of the production of 1914 was made up as follows: Lumber, lath and shingles, $67,500,000; firewood, $60,500,000; pulpwood, $15,500,000; posts and rails, $9,500,000; cross-ties, $9,000,000; square timber exported, $400,000; cooperage, $1,900,000; poles, $700,000; logs exported, $850,000; tanning materials, $22,000; road mining timbers, $500,000; miscellaneous exports, $300,000; and miscellaneous products, $10,000,000. Spruce is the most important wood in Canada for the production of lumber and pulp. Maple is used for firewood as well as for furniture, cars, agricultural implements, hardwood flooring and distillation. Cedar is the most important wood in Canada for poles, fence-posts and rails, cross-ties and shingles. White pine and Douglas fir are important lumber species. Beech, poplar and jack pine are used in large quantities for fire wood. Red pine, hemlock, and tamarack are lumber woods of less importance. Balsam fir is an important pulp-wood. Yellow pine grows in the interior of British Columbia, and covers a large area in the dry belt. Elm is an important cooperage wood, together with oak, ash, and basswood.

A NOVEL RAIL SECTION.

A marked departure from the commonly accepted designs of rails is seen in a rail now in use in 40 ft. of track on the main line of the Minneapolis, St. Paul & Sault Ste. Marie near Minneapolis, Minn. The rail is made up of three separately-rolled members, as shown in the accompanying cross-section. The central portion, shaped like the English bullhead rail, is enclosed except the head, by two T-shaped supporting sections, the three pieces being of such proportions that the central part is supported on the underside of the head and also on the base. Holes are provided in the outstanding legs of the supporting sections for spiking or bolting the rail to the ties. No other fastenings are used either to hold the three portions together or to splice the joints. One advantage claimed for this rail is that by staggering the joints in the centre or tread section with reference to those in the supporting sections, no splices of any kind are required. Another advantage suggested is that the portion subject to wear comprises only one-half the weight of the composite section and can be renewed independently of the supporting portions which are not subject to wear.



Dimensions of the Compound Section.

The rails in use on the "Soo" were installed in November, 1914, and consist for each rail of a 20-ft. length of head section in the centre with a 10-ft. length on either end, supported on two 20-ft. lengths of base sections, thus breaking the joints. A special compromise joint was provided for the connection to the standard rail on either end. Owing to the small amount of this rail used it was not rolled, but was planed out of solid material, a bloom serving as a blank for the head section, while an I-beam served the same purpose for the base section. The track has been inspected frequently, but the length of service has been too short to demonstrate the true merits of the new section. Future developments will be watched with interest. The rails were furnished by the American Safety Steel Rail Company, Bismark, N.D.

German chemists have been trying to find a use for "carbide-mud," or the residue from the union of calcium carbide and water. The "Chemiken Zeitung," Berlin, now states that when mixed with 40 per cent. of building sand this residue makes a very usable mortar, which hardens well and binds stones firmly together.

THE ATTITUDE OF LEGISLATURES TO THE GOOD ROADS MOVEMENT.*

By A. C. Emmett, Winnipeg.

THE attitude of the Provincial Legislatures toward the important question of road-building is becoming more favorable as the economic value of good roads in the development of our great Dominion is better realized. The Province of Quebec is to be especially congratulated on the wideawake policy that has been adopted by the Provincial Government and which is being so successfully carried out.

For many years the granting of aid from the Provincial treasuries towards the construction of good roads was of the most meagre character, and it is only in recent years that the various Provincial Governments have passed Good Roads Acts under which the various municipalities can obtain substantial grants toward the carrying out of a definite and well-defined plan of road improvement in the country districts.

Under the present Good Roads Act of the Province of Manitoba the government gives a grant of fifty per cent. of the total cost of construction of all roads of a permanent character, including all bridges, culverts, etc., necessary to place the highway in perfect condition.

For dirt roads the grant is one-third of the cost. No provision is, however, made for after-maintenance, and this, to me, would appear to be a weak spot in the Act, as, unless roads are properly maintained, the money expended in their construction is, to all intents and purposes, wasted, and there should be a provision in the Act compelling municipalities to make some provision for after-maintenance for a period of time equal to that of the bonds which are issued in payment of the construction work, such bonds being guaranteed by the Government.

The present system of road construction throughout the entire Dominion is not one that is conducive to the best results being obtained, as the work is generally carried out by the municipal councils, who, although interested in the construction of good roads, have not the expert knowledge necessary to see that the best results are being obtained from the expenditure of the ratepayers' money. In order to remedy this state of affairs, it has struck me that the system of road-building would be improved by the placing of all the main highways throughout the Dominion under the charge of the Dominion Government, whose engineers should construct the roads, take care of the maintenance, and the cost of the work be borne from the consolidated revenues of the Dominion.

The second class main roads should come under the control of the Provincial Governments, who would be responsible for their construction and maintenance, and the cost covered from the consolidated revenues of the Province, or in a similar manner to that provided for under Section 20 of the Road Laws of the Province of Quebec, by which the Government may construct or reconstruct roads connecting central points of importance and levy the cost on a mileage basis on municipalities benefited. This, it will be noted, provides the entering wedge for a system of Provincial Roads.

The third class of road would come under the heading of Municipal Roads, and would consist of the local market roads and feeders forming the connecting links between the main highways. The cost of such municipal roads would come under the present system of construction and maintenance by local taxation.

The encouragement of Split Log Drag competitions throughout the Province will also be found of the greatest benefit to the good roads movement. In the Province of Manitoba a Split Log Drag competition has been carried on for several years past by the Manitoba Good Roads Association, and has been so successful that the government has decided to help along the movement this year by a special grant towards the cost of the work. Such a grant will probably take the form of a percentage on the number of miles kept by each municipality under the dragging competition, which will commence with the spring break-up and last until freeze-up. By extending the competition in this manner it will ensure the roads being left in good condition for the winter, which, as everyone will agree, is a most desirable condition, as the smoothness of a road when winter sets in guarantees it being in good condition for shedding the surface water when the spring break-up comes.

It may be said that it is almost impossible to get work done on the roads when the farmers are busy harvesting their crop or hauling grain to the elevators, but this only makes a strong argument for the suggested revision of our road system, as, if the farmer cannot be depended on to do the work when it is most necessary and of the greatest benefit to the agricultural communities, then the work should be done by means that will assure a continuance of work at all times.

I do not wish to offer any suggestions as to the best way of bringing about such a radical change as I have suggested, as there are many delegates to this conference who are more fitted to deal with this question than I am, and I simply desire to see this question discussed by the congress with a view to the improvement of our present road system, which, if only considered from the viewpoint of military necessity, should receive the attention of the Dominion Government, as far as the main highways are concerned.

In conclusion, I would thank the officers of the convention for affording me the opportunity of placing these suggestions before you, and trust that the congress will meet with the success which such a laudable object deserves.

*Paper read before the 3rd Canadian and International Good Roads Congress, Montreal, March 6-10, 1916.

At a case argued before the North Carolina Supreme Court it was established that a power company that owns land on one side only of a stream is not entitled to build a dam to the middle of the stream and divert one-half the water through a flume for use in developing power, although the water be returned to the channel before leaving the company's land. In reaching this decision the court cites New York and Maine cases as upholding the principle that each of opposite riparian owners has an indivisible right to the enjoyment of the full flow of the stream.

The Nord Railway of France has suffered more through the war than any other French railway. In September, 1914, only 414 miles, or 18 per cent. of the total network of 2,324 miles, was actually being operated by the company, which indicates the invaluable military services which the Nord rendered during the earliest stages of the war. To-day the company is operating a total length of about 1,200 miles, or 51.5 per cent. of the entire system. Of the 768 stations on the system, 356 are at present either occupied by the enemy or closed to traffic. Not all the remaining 412 stations are open to the public, a certain number being exclusively reserved for military purposes. The actual situation is that for over a year the Nord has been deprived of the use of most of its great arteries, and the only double-track main line now available is that from Paris to Creil, Amiens, Boulogne, Calais and Hazebrouck

THE USE OF AMMONIA IN THE CHLORINATION OF WATER.

By Joseph Race, F.I.C., City Bacteriologist, Ottawa.

IN the course of some experiments on the effect of color, turbidity, and temperature on the chlorination of water, the writer thought it would be interesting to determine the relative efficiencies of various hypochlorites. Nothing worthy of mention was observed until ammonium hypochlorite was used; this was prepared in solution by the double decomposition of calcium hypochlorite and ammonium oxalate, and great care was exercised to prevent the addition of an excess of oxalate, which, if present, would introduce a factor of unknown value. It was anticipated that the reaction would proceed somewhat along the lines represented by the following equation:

$Ca(OCl)_2$		$(NH_4)_2C_2O_4$		CaC_2O_4		$2NH_4OCl$
Calcium	+	Ammonium	=	Calcium	+	Ammonium
Hypochlorite		Oxalate		Oxalate		Hypochlorite

The calcium oxalate was deposited by centrifuging at a high speed and the supernatant liquid removed for experimental work.

In testing the effect of this solution on a culture of B. Coli Communi or seeded into raw Ottawa River water, the author was very surprised to find that the germicidal value was very much in excess of the hypochlorite of calcium, sodium and potassium. The velocity of the reaction as calculated by the formula

$$K = \frac{\log \frac{N_1}{N_2}}{t_2 - t_1}$$

in which N_1 represents the number of organisms at t_1 and N_2 at t_2, showed that with 0.3 parts per million of available chlorine in each instance, the value of K for ammonium hypochlorite was twenty to thirty times as great as that of calcium hypochlorite. This experiment was confirmed by others which gave similar results.

In searching for an explanation of this phenomenon it occurred to the writer that it was probable that ammonium hypochlorite was exceedingly unstable in dilute solution and spontaneously decomposed into chloramine and water as represented by the following equation:

NH_4OCl		NH_2Cl		H_2O
Ammonium Hypochlorite	=	Chloramine	+	Water

Chloramine has been shown by Rideal (Journal R.S.I., 1910, 31, 33-45) to have a much greater germicidal action than an equivalent of chlorine. Rideal deducted this fact from experiments on the chlorination of sewage in which he found that "the first rapid consumption of chlorine or hypochlorite was succeeded by a slow action which continued for some hours, even days, and was attended by a germicidal power after free chlorine or hypochlorite had disappeared." . . . "It became evident that chlorine, in supplement to its oxidizing action, which had been exhausted, was acting by substitution for hydrogen in ammonia and organic compounds, yielding products more or less germicidal." Rideal supported this by determining the carbolic coefficients of hypochlorite, and of hypochlorite with the addition of an equivalent of ammonia. These gave values of 2.18 and 6.36 respectively. Although Rideal seems to have made this experiment merely for the purpose of explaining an observed phenomenon, it is curious that the possibilities of its practical application to water and sewage disinfection seem to have either been entirely overlooked or discarded on account of economic considerations.

After noting the above-mentioned facts in connection with ammonium hypochlorite, the writer followed up Rideal's work and produced dilute solutions of chloramine by the addition of ammonia to calcium hypochlorite solutions. These had the same germicidal power as the chloramine produced by double decomposition and were approximately three times as efficient as an equal quantity of hypochlorite.

The next step was to determine the relative proportions of hypochlorite and ammonia that would yield the greatest efficiency. The results obtained, though not entirely conclusive as to the most efficient ratio, showed that an increase in the ammonia beyond an equivalent of the chlorine (available chlorine : ammonia as NH_3 = 2 : 1 by weight) did not produce results commensurate with the increase of ammonia. Half an equivalent of ammonia, or chlorine : ammonia = 4 : 1 gave inferior results but the reduction in efficiency was very much smaller than the reduction in the ammonia. The relative proportions of chlorine and ammonia must also be considered from the economic standpoint and when this process is carried out on a large scale, these various considerations will demand a rather fine adjustment.

A remarkable feature of the treatment of water with a mixture of hypochlorite and ammonia is the almost entire absence of absorption. On adding bleach to the Ottawa River water so as to produce a mixture containing 10 parts per million of available chlorine, about 35 per cent. is absorbed in 5 minutes at 60° F. and 60 per cent. within one hour. If an equivalent of ammonia is first added to the bleach, only 1.4 per cent. of the available chlorine is absorbed in one hour and 3.2 per cent. in 20 hours. As there is practically no absorption of the germicidal agent, the longer the contact period the better will be the results obtained. For instantaneous sterilization the relative efficiency ratio of 3 : 1 for the mixture of chlorine and ammonia as compared with chlorine cannot be obtained, but with the increase of contact period the efficiency ratio also increases and after about 40 minutes the ratio becomes greater than 3 : 1. The germicidal action of the mixture continues to persist on account of non-absorption and for a comparatively long time, and as a consequence of this no aftergrowths are produced.

Cost.—Basing the calculations on a ratio of one equivalent of ammonia to one equivalent of available chlorine (0.5 part per million NH_3 to 1.0 p.p.m. available chlorine) a very conservative estimate of the most efficient ratio, this process becomes economical when the price of hypochlorite exceeds $2.08 per 100 pounds. This statement is based on the mixture produced being three times as efficient as hypochlorite: that 33 per cent. of available chlorine can be obtained from bleach and that ammonia can be purchased for 25 cents per pound. The efficiency ratios of 3 : 1 can be obtained under the conditions of chlorination usually found and no alteration in the point of application will be required. Bleach containing more than 33 per cent. of available chlorine can be obtained but very few plants actually extract more than this amount as there are certain losses which are unavoidable. The present price of ammonia (aqua 16° B.) is quoted in the United States at 2¼ to 2½ cents per pound. This solution contains 10.3 per cent. of NH_3 and the anhydrous ammonia is therefore worth 22 to 25 cents per pound. In Ottawa bleach can be obtained for $3.70 per 100 pounds, and by the adoption of the ammonia process the heavy dosage of one part per million of available chlorine re-

quired to treat the Ottawa River water (color 40 p.p.m. platinum scale) can be reduced to 0.33 p.p.m. with a saving of about $7 per day or $2,500 per annum if the laboratory results can be duplicated under service conditions. In the United States, where much higher prices prevail for bleach, the advantage to be gained by the substitution of the ammonia process is, of course, even greater.

Aesthetic Conditions.—For some years it has been considered as at least probable that the fishy odor and taste of heavily chlorinated water was caused, not by the chlorine or hypochlorite, but by substituted nitrogenous compounds. At first sight it would appear that by the addition of the substituted nitrogenous compounds contained in the ammonia mixture, this objection would be accentuated and deprive the process of its practical value. In practice no such result is obtained, and no trace of the added mixture can be detected. As the total amount of chlorine added to the water is only about one-third of the usual dosage, the total amount of chlorine compounds, nitrogenous and otherwise, is only one-third also, and complaints regarding taste and odor should be reduced and not increased by the adoption of the new process unless the compounds produced are totally different in the two cases.

Since writing the above, the author has applied the process to a small plant treating 200,000 Imperial gallons per day and has met with unexpected difficulties. When a 10 per cent. solution of bleach was made and strong ammonia (0.880) added, a rapid loss of available chlorine resulted. This was reduced considerably by diluting the hypochlorite solution before adding the ammonia, but even then the results were not satisfactory. Laboratory experiments confirmed the loss produced by mixing comparatively concentrated solutions and also that the loss could be obviated by immediate dilution with large volumes of water. The arrangements in the experimental plant are now being altered so that the ammonia and hypochlorite will only mix for a few seconds before dilution with the raw water in the intake pipe.

Although various details have yet to be worked out, these notes are published in the hope that others will take up this work and endeavor to work out a process that will give some relief from the present exorbitant price of hypochlorite.

IMPROVEMENTS IN COAL-HANDLING PLANTS.

A COAL-HANDLING plant recently installed at Southend-on-Sea for the Corporation Electric Works, presents some interesting engineering features. It was built by Ed. Bennis & Co., of Little Hulton, Bolton, who were successful in the competition which was held prior to awarding the contract.

The arrangement consists of a series of overhead storage bunkers with a capacity of 500 tons. A bucket elevator raises the coal from a dumping hopper and it is distributed to the bunkers by a conveyer. The dumping hopper is equipped with a Bennis rotary safety feeder, which keeps a steady supply of coal filling the buckets. The elevator is 70 ft. long and will raise 20 tons of coal per hour. It is practically dust-proof. The elevator delivers coal through a chute to a Bennis steel chain conveyer. This consists of a series of mild steel bars pressed into the form of a "U". The chain moves along a rectangular trough and carries the coal with it.

The bunkers are built up of mild steel plates and sections riveted together to form a series of rectangular bins with hopper bottoms. A number of openings are placed in the bottom of each bin and are provided with outlet chutes and radial cut-off valves. The cut-off valves are operated by chains from the firing floor. A swing chute is suspended beneath each outlet for guiding coal from the bunkers to the stoker hoppers. The chutes are made to swing back out of the way when boiler tubes are being cleaned or renewed.

The bunkers have a total length of 106 ft. Their vertical sides are 11 ft. deep, and their top is about 39 ft. above the firing floor level. They are carried on twelve stanchions formed out of rolled steel joists, 27 ft. long, resting on concrete pillars built level with the firing floor. A superstructure is built on top of the bunkers to carry the conveyer, which works in a chamber carried the full length of the bunkers. The sides and roof of the chamber are formed with corrugated sheet in which continuous windows are set in each side. Access is obtained to the conveyer chamber by a ladder on the elevator frame. The extreme height from the bottom of the stanchions to the top of the superstructure is about 56 ft.

Another case which required a different arrangement of the conveying plant was at Wigan. Here the coal is unloaded from barges at a point about 80 ft. away from the boiler house and in the interests of economy it became necessary to provide some effective mechanical means for conveying the coal from the canal to the boiler house. The scheme put into operation is to load the coal by hand from the barges into skips, which are hooked on to a travelling electric transporter running along an overhead track; extending between the boiler house and the canal. The transporter raises the loaded skips and carries them along the overhead track, after which they are emptied into a receiving hopper placed above an automatic weighing machine. The weight of the coal is automatically recorded, and it passes on into a second hopper with two outlets. These outlets feed two chain conveyers, similar to the one in use at Southend-on-Sea, which discharge into two overhead coal bunkers placed about 100 ft. apart.

At this plant the bunkers are 7 ft. 6 in. wide by 7 ft. 9 in. high by 80 ft. long. They are constructed with a framework formed of rolled steel sections with the space between filled in with panels of brickwork and concrete, the whole being braced together to form a rigid structure. Small hoppers are built in the bunker floor, above each chain-grate stoker, and the coal passes by gravity from the bunkers to the stokers through a series of chutes, arranged similarly to those at Southend-on-Sea, so as to swing back and allow access to the boiler tubes. The bunkers are supported on rolled steel joists, built into the boiler house wall, at one end, and supported on stanchions at the other end.

The Orillia Molybdenum Company, Orillia, Ontario, has made its first shipment of two tons of concentrates of molybdenum to the British War Office. This is the first time that such ore has been treated in Canada. The company has received instructions from the War Office to make weekly shipments.

At no time in the history of the pulp and paper industry in Canada was business better than it is at the present time, according to "Pulp and Paper Magazine." It may be true that a few years ago there was a boom and a number of new companies were formed, but their inception was largely the work of promoters and speculators rather than a result of the natural expansion of the industry. To-day, however, business is improving as a result of increased demands. There are nearly a dozen Canadian mills making additions to their plants, increasing their output or preparing to build new mills. A number of other companies are being formed for the purpose of building plants in Northern Ontario and Northern Quebec.

THE HOT-MIX METHOD OF BITUMINOUS CONSTRUCTION, USING AN ASPHALTIC BINDER.*

By Francis P. Smith, Ph.B., M.A.S.C.E., M.A.I.C.E.

FROM among the wide variety of bituminous pavements known at the present time it is almost always possible to select one type which will satisfactorily answer any given set of climatic and traffic conditions. Bituminous pavements, therefore, come nearer to being the universal and ideal type of pavement than any other which has yet been devised by man.

Bituminous pavements, especially those with fine mineral aggregates, are smooth, non-productive of dust, almost noiseless, waterproof, non-absorbent and easy to clean. They are capable of sustaining very heavy traffic, and also last well under light traffic. They are, therefore, well adapted for business and residence streets, and the facility with which they may be kept clean makes them especially desirable in tenement districts. They are easy to repair and offer but slight resistance to traffic. They are somewhat softer in summer than in winter, but when properly laid never become too soft for use, even in the hottest weather. When dry and clean they are not slippery, and their slipperiness in moist or drizzly weather is largely due to the presence of a thin film of mud caused by the collection of street detritus, and this can be greatly reduced by washing or keeping them clean. For this reason they are less slippery in a heavy rain than in a drizzle. Horses accustomed to granite block pavements instinctively put their hoofs down and slide them until they obtain a foothold in the crevices of the pavement. As there are no such crevices in a bituminous pavement, it takes a little time for them to become accustomed to it, but they soon learn to adapt themselves to a smooth surface.

While sheet asphalt will sustain a very heavy traffic, this statement applies more especially to a traffic largely composed of quick-moving, light-to-medium loaded vehicles, such, for instance, as prevails on Fifth Avenue, New York. It is not the most suitable type of pavement for a very dense, slow-moving, heavily-loaded traffic. Wood block and granite block will outlast it under these conditions. It will not give satisfaction where there is practically a total absence of traffic, as it then is liable to develop cracks, apparently requiring the kneading action of traffic to equalize the stresses set up by contraction and expansion and to keep it in proper condition. It is entirely suitable, however, for traffic varying from the light delivery traffic of residence streets to the dense but quick-moving traffic of Fifth Avenue, New York, or the Thames Embankment, London.

On account of their smoothness, sheet asphalt pavements are not suitable for use on excessive grades. Generally speaking, streets carrying a fair amount of traffic can be paved with asphalt if the grade does not exceed 6 per cent. In some cases, where the traffic was very light and a smooth pavement was considered essential, it has been laid on grades running up to 10 per cent. and 12 per cent., but this is rather exceptional. Where the traffic is heavy, a 3 per cent. to 4 per cent. grade is usually considered as the limit. In most of the largest cities of the United States the maximum grades on which this type of pavement is laid vary from 4½ per cent. to 8 per cent., regulated largely by the traffic and climatic conditions.

Depending upon the size of the mineral aggregate used, they may be considered as bituminous mortars or bituminous concretes, differing from ordinary mortars and concretes in having a cementing material which is plastic, and which may be classed as a semi-fluid or semi-solid. For this reason greater care must be taken in the selection of the mineral aggregate and its grading than if a rigid cementing material were employed.

The pavements produced by these mixtures are to a certain extent malleable and yielding, thus minimizing the wear of the mineral particles and making them more acceptable to horse-drawn traffic. In summer these qualities are more noticeable than in winter, for at very low temperatures the asphaltic binder becomes practically rigid. This very quality of flexibility or plasticity makes it necessary to provide a stable foundation. If the foundation is unstable and sinks after the pavement has been put down, the pavement will gradually sink with the foundation, thus forming a depression in which water will collect and eventually destroy it. The wheels of vehicles passing over such depressions will drop into them, the force of the blow depending upon the weight of the load, and this will still further exaggerate the depression by forcing up a portion of the pavement immediately in front of it. It will also set up a vibration in the springs of the vehicle, which will cause successive blows to be dealt to the pavement until the spring vibration returns to the normal. This action, especially in commercial vehicles, where the springs are short and stiff, results, sooner or later, in wave formation, which is unpleasant to ride over, and which, when it once sets in to any considerable extent, rapidly increases until it becomes necessary to re-surface the street or road.

Hot-mixed bituminous pavements differ from each other chiefly in the size and kind of the mineral aggregate, the bituminous cement or binder being substantially the same in each case. Sheet asphalt pavements have a mineral aggregate which contains no particles which would be retained on a one-quarter-inch sieve. Topeka mixture pavements consist of a standard sheet asphalt mixture to which has been added from 15 to 25 per cent. of stone passing a one-quarter-inch screen and retained on a ten-mesh screen and 10 per cent. or less of stone passing a half-inch screen and retained on a one-quarter-inch screen. It is really a type of bituminous concrete pavement, although in certain sections this term is only applied to pavements having a mineral aggregate consisting wholly or largely of stone of varying sizes, from 1½ inches down. The coarser the aggregate used, the rougher will be the surface of the finished pavement. On grades, therefore, where the traffic is not excessively heavy, coarse aggregates are to be preferred. Generally speaking, the heavier the traffic the finer should be the mineral aggregate used, owing to the fact that the coarse particles are more liable to fracture than the smaller particles. Where fracture takes place to any considerable extent rapid deterioration of the pavement will ensue, as the bituminous cement ordinarily used is not sufficiently fluid at atmospheric temperatures to re-bond and re-coat the fractured particles.

This brief consideration of some of the characteristics of bituminous pavements is necessary in order to intelligently discuss the question of proper foundation and the selection of the mineral aggregate to be used.

The character of the foundation required will depend upon the traffic, climate, character of subsoil and drain-

*Read before the 3rd Canadian and International Good Roads Congress at Montreal, March 6-10.

age conditions. The heavier the traffic, the stronger must the foundation be. In cold climates, where the ground freezes to considerable depth in winter, the spring thaws produce a very unstable condition of the subsoil, and in such cases the foundation must be stronger than is required in climates where there is little or no frost. A well-drained sandy soil is much less affected by these temperature changes than is a heavy, clayey soil.

A number of different types of foundations have been successfully employed, such as old macadam; broken stone, rolled dry or cemented together with some form of bituminous cement; old cobblestone, Belgian block or granite sett pavements; old brick or asphalt block pavements; bituminous concrete; natural cement and Portland cement concrete. Where the traffic is light, as on country roads which are not main arteries from or between large cities, and in some residential streets, old macadam roads have proved to be suitable foundations for bituminous surface mixtures.

In some cases, notably the Thames Embankment in London, a foundation of this kind, covered with an asphalt pavement, has successfully carried very heavy traffic, but the layer of stone has been built up during many years and is very thick. Under severe conditions the use of macadam as a foundation is to be deprecated, and more failures than successes have resulted from it.

Many roads are classified as macadam which contain no base course of large stone, and are in reality old dirt roads, which have never been properly drained and on which fine stone has been dumped and consolidated by traffic. Before using any macadam road as a foundation, its history, and more particularly its condition in the spring of the year, should be investigated. A sufficient number of test-holes should be put down to determine the character and depth of the stone and provision made for proper under and side-drainage. It will usually be necessary to rebuild the road in a number of places, and in most instances the crown must be reduced. Wherever possible this should be done by filling up the depression and building up the shoulders. Traffic will compact a road far better than will a roller, and a road surface which has been scarified and rolled will not be as hard and firm as one which has been compacted by years of traffic. Where depressions are to be filled the roadbed should be cleaned and slightly loosened to ensure proper binding of the new stone, which should be of the same size as would be employed in building up the corresponding portion of a new macadam road. It should be thoroughly wetted and rolled with a 10-ton road roller, with the addition of sufficient screenings, until vehicles passing over it do not cause displacement.

Unless this work is thoroughly and conscientiously done the foundation will not be of uniform strength throughout and settlements will occur where the new stone was put. If it is necessary to scarify the road surface, this should be done to the minimum possible depth, after which the surface should be built up exactly as if constructing a new macadam road and rolled until the utmost compaction is obtained. Wherever possible traffic should then be turned upon the road for a few months to develop any weak spots in it and to secure still better compaction.

Old pavements of brick, granite, etc., should not be used as a base if it is first necessary to re-set them. In their original condition they are satisfactory if the traffic is not too heavy. Relaid blocks, until bedded by traffic, are not rigid and have a tendency to rock, and asphalt pavements laid on such foundations in New York City have rapidly disintegrated wherever they were exposed to heavy traffic.

Concrete foundations vary according to conditions from 4 to 9 inches in depth, and in every case before laying them the subsoil should be thoroughly compacted. In certain localities in the north-western portion of the United States and Canada very heavy clay soils are found which in winter frequently develop cracks 4 to 5 inches in width and heave very badly. In such cases cross-trenches should be dug every 25 or 30 feet and filled with coarse broken stone and connected with longitudinal trenches at the side of the street similarly filled and draining to catch-basins. Concrete should not be laid directly on such a soil. Sand or gravel should first be spread upon it to such a depth that when rolled it will form a layer 3 to 4 inches in thickness, and the concrete should be placed on this.

The mineral aggregate constitutes from 75 to 90 per cent. of the pavement and takes practically all the wear resulting from traffic. It must, therefore, be selected with great care. It must be hard enough to carry the traffic; it must have clean grains or particles, and these grains or particles must be graded from coarse to fine, so as to make a pavement of the maximum density with the smallest-sized voids obtainable and with sufficient inherent stability to resist displacement under the shoving action of traffic. The surfaces of the grains or particles must be of such a character that the bituminous cement will adhere satisfactorily to them. Sand, gravel, broken stone or slag, or combinations of them, are the materials used in the type of pavements under discussion.

Sand should be clean-grained, hard and moderately sharp. The grains should be chiefly quartz, and should have rough, pitted surfaces. Where necessary the proper grading of the different-sized grains must be obtained by mixing several sands, or in certain cases by the addition of unweathered crusher screenings. When using the ordinary type of bituminous mixing plants the presence of clay is undesirable, either as a coating to the grains or disseminated throughout the mass. For medium or heavy traffic pavements all particles retained on a 10-mesh screen should be discarded. For light traffic 3 to 5 per cent. of 8-mesh particles can be incorporated in the pavement with advantage, or broken stone of the sizes and in the amounts described under "Topeka Mixture." Sands containing a large amount of flinty grains should be avoided.

Gravel should be clean-grained, hard and free from adhering clayey particles. It is lacking in stability owing to its roundness, and is usually considerably improved by passing it through a crusher. Gravel with a rough, pitted surface is to be preferred and gravel containing a large percentage of flinty particles is to be avoided. It is unsuitable for the construction of pavements carrying heavy traffic and inferior in all respects to crushed stone.

Broken stone should be freshly crushed, preferably in cubical-shaped particles. The size and hardness required depend upon the traffic which the pavement is to carry. Dense, hard limestone will carry medium and light traffic satisfactorily. Where the traffic, even though comparatively light in volume, is composed of heavy, iron-tired units, a dense, hard trap is required. Trap is now commonly used in the manufacture of asphalt block, although in the past a large number of asphalt blocks made from limestone gave excellent service under light

traffic. Granite is not usually satisfactory as it is too coarse and uneven in texture, and much of it is friable and it is liable to shatter in crushing. Mesh composition or grading of the various-sized particles is just as important as with sand. It is not suitable for use in pavements carrying very heavy traffic.

Slag.—Hard, dense, basic slag is to be preferred. It should be stable when exposed to the weather and not show any tendency to slack or disintegrate. It is only suitable for light traffic, and should preferably be coated with a very fluid bitumen.

The filler should be finely-ground limestone or Portland cement, the latter being preferable for mixtures designed to carry extremely heavy traffic. For light traffic the speaker prefers the limestone dust as it does not have such a marked drying effect. Whichever is used, it should be ground so that at least 65 per cent. of it will pass a 200-mesh sieve. Pulverized clay also makes an excellent filler, but is difficult to handle owing to its tendency to ball and cake if it becomes the least bit damp.

The bituminous binder, or asphalt cement, as it is termed in the sheet asphalt industry, must possess such properties that it will firmly bind together the mineral particles and resist the disintegrating action of traffic and the elements. The necessary tests for determining whether or not it is possessed of these properties are fairly well standardized and are embodied in most standard specifications. The time allotted to the speaker will not permit of a detailed discussion of them.

The plant used in the manufacture of the paving mixture is a very important element in the success of the pavement. A uniformly good mixture cannot be turned out by an imperfect plant. The standard type of plant first developed in the sheet asphalt industry has for a long time been recognized as the best for the purpose. In it the sand or stone, or both, are heated in revolving driers and fed by means of elevators into a storage bin. The bituminous cement is heated in properly designed melting kettles.

Measured or weighed (preferably the latter) amounts of the various ingredients are then mixed together in a twin-shaft mixer of the pugmill type. This mixer should have a speed of from 65 to 85 revolutions per minute, and for ordinary work each batch should receive a full minute's mixing. Where the service conditions are very severe it may be necessary to increase the time allowed for mixing, and also raise the temperature at which the mixing is done in order to ensure a thorough coating of the surface of all particles with a firmly adherent film of bituminous cement. Great care must always be taken not to overheat either the mineral aggregate or the bituminous cement, as this will injure and harden the latter. Too low a heat will result in imperfect coating of the mineral particles. Certain asphalts are fluid at much lower temperatures than others, and certain asphalts are very readily injured by overheating while others are not. In the type of plant which we have been considering clay or clayey particles are objectionable, owing to the fact that they either become partly baked on the grains of sand or pieces of stone, or form into lumps which do not detach themselves or break up under the action of the mixer blades. This prevents the bitumen from adhering to the grains, or else results in coating the outside only of the clay balls. Under traffic these balls break up and the bitumen becomes detached from the coated grains, tending toward more or less rapid deterioration of the pavement.

In certain types of plants the grains after heating are subjected to pulverization, which breaks up any clay balls which may have been formed, and which cleans the sand grains or small stone particles. With this type of plant practically any desired amount of fine material may be produced from the mineral aggregate and clay, owing to its great absorbent power and affinity for bitumen, is a distinct advantage.

Plants of the concrete mixer type, in which the heating and mixing are done in one revolving chamber, are not to be recommended. As usually arranged, they are inefficient driers and very inefficient mixers, and are liable to burn the bituminous cement if the flame is permitted to come in contact with it. The only way to avoid this source of danger is to heat the bitumen and the mineral aggregate separately and not to heat them in any way during the mixing process.

The construction of the bituminous portion of the pavement is not the same for all types. Where coarse aggregates are used, from two to three inches of the surface mixture are usually laid directly on the foundation. It is very difficult to completely close up such mixture by rolling. It is usually, therefore, given a squeegee coat of hot bituminous cement, after which stone chips are spread over the surface and rolled in, the excess being left to be ground away by traffic.

Topeka mixture pavements are laid from 2 to 3 inches thick, and are frequently placed directly on the foundation. Much better results are obtained by using a binder course 1½ inches thick next to the foundation, with a 1½ to 2-inch wearing surface. This greatly reduces the tendency of the finished pavement to shove. With a well-graded mixture a squeegee coat is unnecessary, although it is frequently employed.

The bitumen contents of coarse aggregate mixtures must be very closely watched and kept within much closer limits than are necessary with sheet asphalt mixtures. One-half per cent. above or below normal is about the permissible variation. Too little bitumen will make a pavement which is too open and porous and too much bitumen will render the pavement very liable to shoving.

The standard sheet asphalt construction of the present day is 1½ inches of binder and 1½ inches of wearing surface. The binder should be of the "close" type; i.e., should contain approximately 25 per cent. of material passing an 8-mesh sieve.

A close binder, properly made and laid, will be superior in many respects to the mixtures which have been laid on a large number of country highways, and will carry a fair amount of traffic for a considerable time without suffering any serious damage. Poor binder will break up very easily—sometimes it can be kicked up—and the hauling of the hot surface mixture over it will damage it very seriously. Surface mixture laid on a binder of this kind which has been badly broken up might almost as well be laid on loose broken stone, and will not give satisfactory service under heavy traffic. The binder should, of course, be thoroughly compressed with a steam roller before laying the wearing surface on it. Lack of compression will produce an unsatisfactory foundation for the wearing surface, and binder which is too cold, or made with too hard an asphalt cement or an insufficient quantity of asphalt cement, cannot be properly compressed into a dense, tough mass. In hauling the binder to the street over long distances or in very cold weather, it may become chilled below the danger point. During the hauling process a certain amount of surplus asphalt cement usually drains off of the stone

and accumulates on the bottom of the cart or wagon. If these excessively rich portions be laid on the street, what are called rich or fat spots in the binder course will be produced. As the name implies, these are places carrying an excess of asphalt cement. If these are permitted to remain, the surplus asphalt cement will be absorbed by the hot surface mixture when it is placed over them. This will make a soft spot in the finished pavement, which will be displaced by traffic, and eventually produce a hole or depression in the pavement. They should, therefore, be cut out and replaced with normal binder.

Before laying the surface mixture on the finished binder course the latter should be dry and swept clean of dirt; otherwise the layer of wearing surface will not adhere properly to it. Binder should be covered with surface mixture as soon as practicable after laying it. In many large cities it is required that all binder laid should be covered the same day with surface mixture.

When delivered upon the street the surface mixture should be of such a temperature that it can be properly compressed, and should be evenly spread by means of hot iron rakes. In many cases the loads of hot surface mixture are dumped directly upon the spot over which they are to be spread. This is bad practice, as the men trample upon it while shovelling and raking it, and the rakes do not thoroughly loosen up this trampled material when passing over and through it. Although the mixture is raked to a uniform surface and apparently even thickness before it is rolled, those portions which have been trampled on before and during raking are really covered with a greater quantity of surface mixture than those portions which have not been trampled on, and which are covered wholly with what might be termed loose or fluffy mixture. When the roller has completed its work there will, therefore, be a slight unevenness in the finished surface. Under light traffic this would make no appreciable difference, but under very heavy traffic the slight pounding action resulting from this condition would be detrimental and lead to uneven wear of the pavement. Proper and thorough compression of the finished mixture is very essential, as this produces a pavement which in its earliest stages is fit to sustain the heaviest traffic. It is always questionable whether portions which are very lacking in compression will be ground out or eventually consolidated. Under unfavorable conditions the chances are strongly in favor of their being ground out. In those portions of the pavement which are inaccessible to the roller compression is effected by the use of hot smoothers or tampers, or both. If properly handled, the desired results will be obtained, but if used too hot they will burn the pavement and cause it to scale or grind out. Hot smoothers particularly are dangerous tools to put in the hands of incompetent or careless workmen.

Extreme care should be taken to ensure a proper union between the surface laid on successive days. The first loads laid in the morning at the termination of the previous day's work should be a little hotter than normal so that the hot mixture may soften the cold edge of the pavement and bond perfectly to it. The joint should be bevelled and freshly cut away unless the rope joint or a similar method is employed.

The practice of painting the edge of the joint with hot asphalt cement is not to be recommended as, unless extreme care is exercised, too much asphalt cement will be used and that portion of the pavement will be too rich in bitumen, and consequently softer than the rest, which will result in uneven wear, and possibly shoving. Great care should be taken not to leave any hump or depression where the joint is made.

The following are typical analyses of the various types of pavements which have been discussed in this paper:—

	Sheet Asphalt Heavy Traffic	Sheet Asphalt Light Traffic	Topeka Mixture	Bituminous Concrete
Bitumen	11.0%	10.5%	8.5%	7.0%
Passing 200-mesh	14.0%	10.5%	8.5%	5.0%
" 100-mesh	14.0%	10.0%	6.0%	4.0%
" 80-mesh	13.0%	10.0%	6.0%	2.0%
" 50-mesh	19.0%	14.0%	6.0%	5.0%
" 40-mesh	11.0%	14.0%	10.0%	4.0%
" 30-mesh	10.0%	13.0%	10.0%	4.0%
" 20-mesh	5.0%	10.0%	9.0%	3.0%
" 10-mesh	3.0%	8.0%	6.0%	5.0%
" 8-mesh	...	...	6.0%	3.0%
" 4-mesh	...	...	14.0%	7.0%
" 2-mesh	...	...	10.0%	20.0%
" ¾-inch	...	...	...	14.0%
" 1¼-inch	...	...	...	12.0%
" 1½-inch	...	...	...	5.0%
	100.0%	100.0%	100.0%	100.0%

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended February 25th, 1916:—

Dominion Reduction Company, 88,000; McKinley-Darragh-Savage Mines, 86,762. Total, 174,762 pounds, or 87 tons.

The total shipments since January 1st, 1916, are now 4,253,414 pounds, or 2,126.7 tons.

RAILROAD EARNINGS.

The following are the weekly railroad earnings for February:—

Canadian Pacific Railway.

	1916.	1915.	
Feb. 7	$1,876,000	$1,440,000	+ $436,000
Feb. 14	1,912,000	1,634,000	+ 278,000
Feb. 21	2,093,000	1,614,000	+ 479,000
Feb. 29	2,665,000	1,815,000	+ 850,000
Month's increase =	31.4%	or	+ 2,043,000

Grand Trunk Railway.

Feb. 7	$ 937,937	$ 786,158	+ $151,779
Feb. 14	957,195	817,255	+ 139,940
Feb. 21	963,484	823,436	+ 140,048
Feb. 29	1,174,099	899,187	+ 275,912
Month's increase =	21.3%	or	+ ......

Canadian Northern Railway.

Feb. 7	$ 429,400	$ 357,100	+ $ 72,300
Feb. 14	453,100	380,500	+ 72,600
Feb. 21	559,000	418,200	+ 140,800
Feb. 29	647,700	446,400	+ 201,300
Month's increase	30.3%	or	+ 487,000

The Canadian Pacific Railway January returns compared with returns of a year ago are as below:—

	1916	1915.	
Gross	$ 8,588,826	$ 6,109,026	+ $ 2,479,700
Expenditure	6,498,417	4,968,793	+ 1,529,624
Net	$ 2,090,408	$ 1,140,233	+ $ 950,174

For the seven months ended January 31st, the comparisons are:—

	1916.	1915.	
Gross	$75,058,989	$62,047,152	+ $13,011,837
Expenditure	43,344,394	41,233,342	+ 2,111,051
Net	$31,714,595	$20,813,809	+ $10,900,785

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION

DELEGATES FROM ALL PARTS OF CANADA AND UNITED STATES MEET IN MONTREAL MARCH 6 TO 10.

THE most successful congress of the Good Roads men, under the auspices of the Dominion Good Roads Association and the Canadian Automobile Federation, was held last week in Montreal. The convention opened on Monday, March 6th, and concluded on Friday, the 10th.

Equalled in importance by few other annual conventions, inasmuch as the deliberations which will result, and the practical suggestions which must come as a matter of course, entail the advancement, the improvement and perfecting of one of the country's great assets —good roads—which must be carried along to that standard towards which other endeavors are being aimed if the promised all-round prosperity is to come to Canada.

The chairman of the convention was the president of the congress, B. Michaud, Deputy Minister of Roads for Quebec Province. The list of prominent men in the provincial life of Canada who attended the opening were many, there being present the Lieutenant-Governor, Hon. P. E. Leblanc; Hon. J. A. Tessier, Minister of Roads; Hon. J. E. Caron, Minister of Agriculture; U. H. Dandurand, honorary president of the Dominion Good Roads Association; Hon. Jeremie Decarie, Provincial Secretary; Monsignor Roy, representing Archbishop Bruchesi; Bishop Farthing, Controller Thomas Cote and I. A. Sanderson, representing the Ontario Good Roads Association.

The delegates came, from all parts of the country and many were present from the large centres of the United States, where the good roads problem is considered a vital one. President B. Michaud, Deputy Minister of Roads for Quebec province, formally welcomed the delegates, and remarked on the honor it was for the convention to be opened by the Lieutenant-Governor, Hon. P. E. Leblanc. Mr. Michaud laid stress on the importance of the many scientific addresses to be heard and discussed. He said he was exceedingly glad to welcome delegates from sister provinces and from the United States.

His Honor the Lieutenant-Governor said the good roads question was one of vital importance. They provided the means of communication, placed citizens of the various municipalities in the position of relationship which was the basis of the progress and the welfare of the country. He paid tribute to the Roman road-makers and the builders of good highways in the time of Napoleon, remarking that these roads were still the objects of admiration in Great Britain and in France. The Lieutenant-Governor said that the Province of Quebec was now delving energetically into the good road work and wished for the co-operation of everyone interested in the advancement of these great national assets.

U. H. Dandurand, honorary president of the Dominion Good Roads Association, remarked on the increase year by year which he had noticed at conventions. He said such a widespread interest in the good roads movement was bound to be productive of great results, and must surely bring the ardent advocate of a well-built highway nearer his aspirations. He said results could even be seen to-day throughout the province, where improvement in roads is already growing apace. Many other speakers took part in the opening ceremonies, the theme of all their statements being the benefits accruing from good roads.

The annual banquet was held at the Place Viger Hotel, nearly two hundred citizens and visitors sitting down to a sumptuous repast. The toast to his Majesty the King was fittingly honored. The toasts to the "Guests" and the "Press" were responsible for several neat speeches.

Alderman Leslie Boyd, K.C., dealt on the aim of the Provincial Government to make the roads in the home province second to none in the Dominion, but he urged that the money of the public spent on this road development be expended wisely. Turning to Montreal, the speaker said the lines of communication with other municipalities must be improved; there must come better facilities for entering the city. He pointed out the extreme importance of the improvement of the roads of the province so that some of the beauties of our interior could be reached by the wealth of tourists who every year streamed in across the border. He extended the best wishes of the city of Montreal to the roads congress.

Mr. B. Michaud paid tribute to the business men of the province, who are lending every assistance to the good roads campaign, while Mr. Tessier gave some interesting information as to the progress in road work which the Provincial Government had made in the past two years. He predicted even more and better roads this year.

Hon. Jeremie Decarie laid stress on the importance of the road—one of the national means of communication. "When we are building up the roads," said Mr. Decarie, "we are building up the country." He then went on to a scathing denunciation of the contractor on road work who would aim for personal profit before a good product, saying that the conscience of the contractor must be equal to the task he had to do.

G. W. Levesque, M.L.A. for Laval county, proposed the health of the "Press," making a neat and eloquent speech, which was responded to by one of the representatives of the press present.

The convention got down to real business on Tuesday morning, when the technical papers and discussions took up the delegates' attention. At this session, presided over by B. Michaud, Deputy Minister of Roads for Quebec, the chief feature was one not on the programme, it being an address by Thomas Adams, the English town-planning expert, on "Town Planning and Good Roads in Rural Municipalities." After declaring that the farmer's interests should be dominant in the rural regions, he met the objection that town-planning had no connection with the farmer by pointing out that in its larger sense town-planning meant the regulating of the use and development of land in the light of future needs. Neglect of this precaution meant waste and loss on capital, and this meant loss for the farmer, who in the end suffered as much from bad government in nearby

cities as the city dweller himself. Referring to the fact that city roads, particularly in the suburbs, were often worse than those through the country, Mr. Adams pointed out the need for closer co-operation between the road-makers of the city and the country. As a means to this, he made two suggestions, one being that the province give municipalities the power to adopt town-planning schemes fitting in with the government's skeleton plan for through highways and radiating rural roads, and the other being the creation of a provincial department of municipal affairs to co-operate with the department of roads.

W. Huber, engineer of the Ontario Highways Department, emphasized the importance of maintenance in macadam roads. "Any scheme of macadam road is highly incomplete," he said, "which does not provide for constant maintenance." Owing to the heavy motor traffic in the present day, he said, stone screenings, as a binder for wearing surfaces, had reached the end of their usefulness.

Francis P. Smith, consulting engineer, of New York, read his paper, "The Hot-Mix Method of Bituminous Construction, Using an Asphaltic Binder," which is published in another part of this journal.

The paper on "Road Maintenance, Materials and Methods," by Mr. W. H. Connell, chief of the Bureau of Highways, Philadelphia, emphasized the same point made by Mr. Huber in the morning, as to the importance of maintenance. A good organization was essential to proper maintenance, he said, but this organization should be a part of the construction organization, as otherwise there would be overlapping and shifting of responsibility, while the intimate knowledge of minute details of each separate piece of construction possessed by the builders would help them immensely in securing proper maintenance. In many sections, where the good roads out-number the bad, maintenance work and cost take a predominant place over construction, and this condition will increase as the good roads movement spreads and achieves its results. Mr. Connell pointed out that in one regard maintenance work was more difficult and intricate than construction, for the builder has standard specifications and the experience of others to guide him, and cannot easily go wrong, but each problem of maintenance and repair brings its own individual difficulties to be solved by those in charge. After speaking of the vital importance of close personal observation of the effect of traffic, climate and other conditions upon pavements as an aid to their maintenance, Mr. Connell treated specifically of methods under the three heads of routine, general and emergency maintenance.

J. W. Levesque, M.L.A., spoke in French on provincial aid for roads, as they have it in Quebec province, and E. Fafard, superintendent of the plants branch of the Highways Department of Quebec, in the French langauge, pointed out how to handle and take care of road machinery.

The concluding paper of the day was an especially valuable contribution to the available data on road maintenance. Its title was "The Cost of Maintaining New York State's Highways," the author being F. W. Sarr, Deputy State Highway Commissioner. After pointing out that the State had paid in 1915 the sum of $4,210,575 under the head of maintenance and repairs, Mr. Sarr gave the following statistics of the average expenditure for maintenance, repair and reconstruction per mile per year for each of seven types of road: 193 miles of gravel roads cost $955 per mile; 2,298 miles of water-bound macadam roads cost $1,055 per mile; 2,387 miles of bituminous macadam, penetration method roads, cost $510 per mile; 63 miles of bituminous macadam, mixing method roads, cost $181 per mile; 295 miles of concrete bituminous roads cost $1,050 per mile; 84 miles of first-class concrete roads cost $129 per mile; 291 miles of block pavement roads cost $190 per mile. The 5,611 miles of all types cost $750 per mile.

At the Wednesday morning session, A. C. Emmett, whose paper appears in this issue, secretary of the Automobile Club, of Winnipeg, spoke on the attitude of legislatures to the good roads movement, which is becoming much more favorable as the economic value of good roads is realized. For many years the grants made were meagre, but many provincial governments had now passed good roads acts, and the various municipalities can obtain substantial grants towards definite and well-defined plans of road improvement in country districts.

The paper of Gabriel Henry, Quebec Government Engineering Department, dealt with gravelled roads, and was read by J. Duchastel de Montrouge, of Outremont. Mr. Henry pointed out that one of the advantages of well-constructed gravelled roads was that they could be made to serve later as foundations for a more costly top course, and one of greater resistance if traffic increased and circumstances demanded, just as earth roads made an excellent foundation for gravelled roads. He emphasized the importance of a perfect drainage for the surface and subterranean waters, these two conditions being indispensable for any road.

The congress unanimously passed a resolution endorsing the establishment of a Dominion Labor Bureau system, permanently administered by a non-political commission, as a national organization indispensable to the adjustment of post-war conditions and the replacing of thousands of able-bodied soldiers in civilian employment when peace is declared.

J. Duchastel de Montrouge, city engineer of Outremont, gave a paper, which is reproduced in these pages, on the laying of brick pavements in Outremont, emphazing the need of the strictest supervision in laying them, and claiming that when properly constructed they will wear smooth without being slippery. They are the most sanitary pavements known, being easily cleaned and absolutely dust-proof; they are practically noiseless, and are economic in the long run, as they required very little attention and maintenance, and can be easily cut through when required and repaired at small cost without any cumbersome plant.

The great war and the good roads issue were intimately associated in a brief but vigorous communication read at the afternoon session. The writer, Oliver Hezzlewood, is president of the Canadian Automobile Federation, and has been in the forefront of the good roads movement since its inauguration in Canada. Unless aggressive action was taken by the Dominion and provincial governments, he said, the carrying out of the plans for good roads was likely to be as haphazard and capricious as the present plans for recruiting for overseas service. The latter system, he claimed, was proving but a repetition of the experience of the promoters of the good roads movement, for many individuals and communities were obviously shirking their plain duty and their responsibility to others and to themselves. Mr. Hezzlewood said that he was rapidly coming to believe in the principle of conscription in all matters of grave public concern, and not alone in recruiting. Canada's whole energies for the time must be devoted to aiding the

Allies to triumph, but when that was accomplished, the Dominion and the provinces should set themselves to carrying out a country-wide scheme of improved roads, thereby taking one of the most necessary steps toward developing fully the resources of Canada. In the meantime, it would not be wise to project any great public works, even such desirable ones as good roads, which might prove a detriment to recruiting. To put 500,000 Canadians into khaki and carry on necessary industries at home would take every available ounce of man-power in Canada, and it would be folly to divert farm labor, for instance, to the making of roads. One form of labor available for the latter work, however, was that of the thousands of enemy aliens interned in Canada, and Mr. Hezzlewood urged that they be employed for this purpose. Reverting to his growing conviction that some form of national service should be imposed for the general welfare, Mr. Hezzlewood said that control over the roads should be taken from county councils and small municipal bodies, and handed over to central organizations, so that in time Canada should have a comprehensive system of highways.

Papers on the allied subjects of "Highway Bridges" and "Highway Culverts" were read, the former by the author, Lucius E. Allen, engineer for the county of Hastings, Ontario, and the latter, in French, written by Alex. Fraser, engineer of the Highways Department of Quebec Province, and read by J. Duchastel de Montrouge, of Outremont. As bridges constitute so large a proportion of the cost of many highways, said Mr. Allen, careful study of their design and construction was necessary. A bridge should be practically permanent in its construction, and, to secure this, careful design, selection of proper materials and expert workmanship must be combined. Solid foundation was the first desideratum. There was no standard type of bridge, and traffic, climate, geographical features and other local conditions must govern a selection. Future developments must be anticipated, as, for instance, the denudation of forests, increasing the possibility of freshets. As a rule, increases of traffic and heavier loads must also be provided for. Reinforced concrete construction was being largely favored in England, being economical both in first cost and in maintenance. In adopting this type, artistic design and finish should not be neglected. If steel bridges were adopted, constant painting was essential, and Mr. Allen said he had seen good steel bridges practically destroyed in 12 to 15 years by neglect of this precaution. In conclusion, he expressed satisfaction that the study of bridges was receiving the consideration it deserved, as this meant that, when the Canadian system of national highways was inaugurated, the bridges built would be worthy of such a great undertaking.

Mr. Fraser's paper on culverts stated that the average cost of permanent culverts on provincial roads in Quebec varied from $800 to $1,500 per mile. Concrete culverts only were used, and, while the Quebec makers in the past had not always adopted the best methods of manufacture, a movement was now on foot to organize in order to secure a standard product. No matter how good the quality of the product, there was danger of failure unless it was properly placed, and the need for intelligent and experienced foremen was imperative. To safeguard traffic, the culverts should be the full width of the road surface, and to secure the unobstructed flow of water, right angle connections between ditches and culverts must be avoided.

Mr. A. E. Cunningham, representing the Lethbridge Board of Trade, spoke briefly. The importance of highways to the country, he said, would be understood when it was remembered that practically every bushel of Western Canada's 300,000,000-bushel yield must pass over some highway in its first stage of transportation. Great interest was being taken in roads in Alberta, and, when the Canadian National Highway was built, it would find Alberta's good roads ready to be linked up with it. The West was eager to secure the next congress for Winnipeg, and an invitation to that effect might be expected before the present gathering closed. Good roads were a magnet that would draw the whole Dominion closer together.

The closing feature of the afternoon was an illustrated lecture by Prof. J. Crandell, of the Pennsylvania State College, on bituminous roads. "You wouldn't put an $8,000 house on a mud foundation," he said early in his lecture, "and it would be equally foolish to use a mud foundation for a road that costs $8,000 a mile." After getting a good foundation, thorough rolling was half the game in building the road. The modern bituminous road was the result of a happy combination of the chemist, the manufacturer and the engineer. The lantern views and moving pictures accompanying the lecture were watched by hundreds of the delegates.

The Canadian Automobile Federation, which was allied with the Dominion Good Roads Association in promoting the Congress, held their annual meeting in the Place Viger Hotel on Wednesday evening.

On the motion of U. H. Dandurand, seconded by L. B. Howland, Toronto, it was decided to change the name of the organization to the "Canadian Automobile Association." L. B. Howland, president of the Ontario Motor League, was elected president; Frank Carrol, Quebec, and A. C. Emmett, secretary of the Manitoba Motor League, vice-presidents; W. G. Robertson, secretary of the Ontario Motor League, secretary-treasurer; Oliver Hezzlewood, the retiring president, was chosen honorary president. The executive committee named is G. A. McNamee, secretary of the Automobile Club of Canada; L. C. Beaupre, secretary of the Quebec Automobile Club; W. G. Robertson, secretary of the Ontario Motor League; A. C. Emmett, secretary of the Manitoba Motor League; and L. B. Howland, president of the Ontario Motor League.

Committee appointments were: J. A. Davis, of Montreal, chairman of Good Roads Committee; E. A. Cunningham, of Lethbridge, chairman of Touring Committee; and U. H. Dandurand, of Montreal, chairman of the Legislative Committee.

The association represents one hundred automobile clubs. The financial state is very satisfactory. At Thursday's session the attendance of delegates was as large as at the previous session and close attention was given to the proceedings.

A snowstorm was responsible for a delay in the commencement of the morning session, proceedings not beginning until 11 o'clock, while several speakers on the programme did not arrive until the afternoon.

Mr. B. Michaud, Deputy Minister of Roads, addressed the delegates on the methods employed in Quebec to construct roads. The various types of roads and the need of economy were covered by Mr. Michaud in his address.

An able paper was read by Mr. Duchastel, entitled "Road Drainage and Foundations." The paper was written by Major W. W. Crosby, consulting engineer, of Baltimore, Md., who was unable to be present.

President Michaud occupied the chair at the afternoon meeting, and some informative addresses and papers were delivered. The first speaker was Mayor Lavigueur, of

Quebec, who told of what was being done in that city, and its vicinity.

One of the most interesting papers of the congress was given by Col. W. D. Sohier, chairman of the Massachusetts Highway Commission, Boston, whose subject was the selection of the type of road surface as governed by the volume and class of traffic. Col. Sohier has been at previous congresses, and his addresses have always been most popular because of his wide knowledge of the subject of roads, and the close study he has made of traffic conditions on the state highways across the border. He pointed out that it was often a difficult matter for an engineer to decide what kind of road he was going to lay down, not merely because of the question of cost, but because often the materials that would give the best results were not always available or to be secured at reasonable expense. He said that without adequate drainage, any road would soon be destroyed and would become a series of pot-holes and ruts with a horse path in the middle full of mud. That did not constitute a road, even if the public had to travel over many miles of such abominations in both countries.

"You must expect in Canada," said Col. Sohier, "when you get an even reasonably passable road leading from New York and the New England States into your beautiful country, that the motorist will soon find it out and you will probably, on a few main roads, have as much traffic as on the average state highways in the United States—500 or more cars every day during the season. You must anticipate this traffic and build your roads accordingly."

Col. Sohier said that with increasing traffic the width of the hardened surface had to be increased, and therefore it was important, if engineers were laying out a road, to be sure to secure a sufficient width to avoid costly extensions afterwards. He mentioned that some of the roads built in Massachusetts, which gave every indication of being economical and extremely satisfactory for any reasonable volume of traffic, were made of clean gravel almost free from loam or clay, heated and mixed with a hot asphaltic residuum or asphalt, the cost of which was about the same as waterbound macadam road when the gravel could be obtained near the road.

Col. Sohier said that when once a road had been treated with some bituminous binder on the top it was not the automobile traffic on pneumatic tires that wore it out, but the crushing weight of heavily loaded teams and trucks. If these were in sufficient number to wear out the stone in a macadam road in five or six years, there was no question that such a road was not only not economical, but was never in good condition for the traffic, and a more expensive and durable type of pavement should be used.

One mile of road in good order was a better argument for good roads and would produce more votes, more money and more good road advocates in one year than all the conventions and speeches delivered in thirty years. Col. Sohier paid a graceful tribute to the knowledge of the deputy ministers for Quebec and Ontario, who were frequent visitors to the United States, where their advice was always welcomed. He generally complimented the engineers and committees doing the road work in Canada.

"Snow Removal in Montreal" was the subject of Chief Engineer Mercier's paper. The average snowfall for 41 years had been 119 inches yearly, and there was snow on 79 days in 1915, with rain on 28 of these days. Mr. Mercier described the methods by which the city and the Tramways Company co-operated to clear the streets, speaking of the Tramways organization under Superintendent A. Gaboury as "wonderful." The cost of cleaning sidewalks was 7½ cents per running foot, and clearing the roads cost $2,500 per mile.

"Concrete Highways and Streets" was the title of a paper by Percy H. Wilson, consulting engineer, Philadelphia. The increase of motor over horse-drawn traffic in the past 15 years, he said, had forced recognition of the fact that "good roads" were synonymous with "hard-surface" roads. He illustrated the increase in motor traffic by citing Ontario, with one auto to every 4,000 inhabitants in 1905, and one to every 75 in 1915, a 5,000 per cent. increase in ten years. The resultant increase in maintenance of macadam roads had created a demand for a hard-surface, all-year, moderate first cost and a minimum maintenance road, and this, Mr. Wilson said, was found in the concrete road. He then went thoroughly into methods of using cement for road-making.

W. A. Magor laid before the gathering the details of the proposed Queen Alexandra Highway, running north of the C.P.R. from Montreal West to Ste. Anne's, being a continuation of Sherbrooke Street to the west end of the Island of Montreal.

At the annual meeting of the Dominion Good Roads Association held on Friday, Winnipeg was decided on as the place of meeting for the 1917 convention. The officers elected for the ensuing year are:

J. Duchastel de Montrouge, Outremont, president; S. L. Squire, Toronto, vice-president; George A. McNamee, Montreal, secretary-treasurer.

It was decided to create an advisory board, which will be composed of the past presidents of the association, as follows: W. A. MacLean, Deputy Minister of Highways for Ontario, Toronto; U. H. Dandurand, Montreal; B. Michaud, Deputy Minister of Roads, Quebec, and O. Hezzlewood, Toronto.

The executive of the association will be composed of: E. A. Cunningham, Lethbridge; A. C. Emmett, Winnipeg; Howard W. Pillow, Montreal; J. A. Sanderson, Oxford Station, Ont.; Thos. Adams, Ottawa; E. N. Desaulniers, M.P.P., Chambly; W. A. Levesque, M.P.P., Montreal; George Hogarth, Toronto, and A. F. Macallum, Hamilton.

The exhibition of the manufacturers of apparatus for good roads making and for materials used in construction was one of the best of its kind ever seen in Canada. Prominent among the exhibitors were: The Asphalt & Supply Co., Limited, Montreal; The Canada Cement Co., Limited, Montreal; The Canadian Fairbanks-Morse Co., Limited, Montreal; Creosoted Block Paving Co., Limited, Toronto; The Dunn Wire-Cut-Lug Brick Co., Conneaut, Ohio; The Imperial Oil Co., Limited, Montreal; T. A. Morrison & Co., Montreal; The Paterson Manufacturing Co., Limited, Montreal; The Pedlar People, Limited, Montreal; Sawyer-Massey Co., Limited, Hamilton, Ont.; Trussed Concrete Steel Co. of Canada, Limited, Montreal.

A correspondent of the "Freeman's Journal," who has visited the British front in Flanders, states: "It is natural to suppose that where there is such an enormous amount of heavy traffic the roads would be greatly cut up and in winter weather soon rendered impassable. So they would were their repair and constant attention neglected or overlooked. But it is not by any means. The roads receive constant attention. If there are soldiers in the trenches and soldiers in the billets, there are also soldiers looking after the roads, and these men perform duties quite as important as those in the actual fighting line. The older men or those who are incapacitated from active military duties are engaged in road-mending and road-making, with the result that all the roads are in a good state and quite fit for heavy traction."

CONSTRUCTION AND MAINTENANCE OF BRICK ROADS AND STREETS.*

By J. Duchastel, M.Can.Soc.C.E.

One of the principal aims of road conventions of this nature should be, in my mind, the education of the public to the general details of the construction and maintenance of some of the principal standard pavements. This can only be obtained by honest talks in the simplest terms possible, devoid of all the exaggerated statements and impossible claims which are so frequently advanced by parties interested solely in the selling of some kind of paving material.

The common man on the street should be made to take some interest in the cause we are all trying to advance here to-day, and demand good roads and still better roads, knowing that he can get them if he has a good knowledge of what he wants.

Since the last fifteen or twenty years, or, to be more precise, since the advent of the automobile as a real factor in traffic problems, the engineers have been eagerly at work trying to meet in an efficient manner the very serious and new problems as they arose in rapid succession.

Hundreds of mistakes have been made through this period, but we must be very thankful that many thousands of road builders have profited by these same mistakes, and to-day the fertile profession of engineering has seen some of its members branch off in a new specialty as highway engineers. Some of these distinguished highway engineers are here gathered at this meeting. The paper I am presenting to-day is not for their benefit, but I will be most satisfied if it meets with their approval. My only object is, in complying with the wishes of our worthy president, Mr. Michaud, to do my little bit and give to the people who follow these road conventions, or read their proceedings, the results of my experience in the matter.

Before going any further I want it distinctly understood that I am not to be classed as a crank on brick pavements, and that I firmly believe that the merits of all types of pavements for any special locality should be carefully considered before any decision is arrived at, so that my judgment on the matter must be accepted as an unbiased one.

The main principles governing the construction of a brick pavement are as follows:—

(1) The proper and efficient drainage of the subsoil, most important in our climate.

(2) The careful compacting of the sub-soil and the shaping of same to a grade to correspond with that of the finished pavement.

(3) The construction of a proper concrete foundation. Most necessary in cold climates and in localities where the drainage of the sub-soil is sluggish.

(4) The adoption of a cushion layer between the concrete foundation and the bricks.

(5) The careful laying of the bricks with the smoothest surface up and lugs laying in the same direction.

(6) The thorough rolling of the ungrouted bricks to an even surface.

(7) The thorough application of a proper cement filler.

(8) The protection of the filler from rapid setting.

(9) The prevention of traffic over the new pavement for a period of two or three weeks.

(10) The competent supervision of the whole work by efficient men.

*Paper read before the 3rd Canadian and International Good Roads Congress, Montreal, March 6-1

Allow me to discuss these important items in detail in describing to you the manner in which a wire cut lug brick pavement was constructed on Laurier Avenue, in Outremont, Que., last year, under my supervision, by day labor.

Laurier Avenue is the main commercial street in Outremont; it runs in a southwesterly direction from Hutchison Street to Cote St. Catherine Road. The distance between the curb lines is 57 ft. 6 in. and its length is 1,092 ft. The grades of this street vary from 2.65% to 4.52%. A double line of car tracks occupies its centre.

The paving work was carried out in the following manner:—

The old macadam pavement on the northwest side was first excavated and both car tracks were pulled over to this side overnight; then the Tramway Company installed new 115-lb. grooved rails on new cedar ties on a concrete slab 18 feet wide by an average thickness of 8 inches, constructed by the city. The pavement between the tracks was then completed, and after a period of fifteen days the street cars were allowed to run over the new tracks. After the old rails had been removed from the northwest side, the paving operations were immediately started. Traffic was allowed to circulate throughout these

Fig. 1.—Laying Brick at Outremont, P.Q.

operations on the opposite side, and as soon as the pavement on the northwest side had properly set it was transferred over to this side and the paving operations begun on the southeast side.

I shall describe only the construction of the pavement on the two sections between rail and curb line, the paving between the tracks being carried out somewhat differently on account of the presence of the rails themselves.

(1) **Drainage.**—The sub-soil encountered in the excavation was quite varied; bed rock at one end and common dirt excavation at the other with rock underlying. This sub-soil had been many times disturbed by the construction of sewer, water, and gas services in separate cuts, as well as the connections to same from the dwellings along this street. Three lines of porous drain pipe 4 ins. in diameter were laid; two at the curbs at an average depth of 12 inches below their level and connected to the catch basins; the third line was laid in the centre of the street below the concrete slab under the ties and connected to the manholes. The shallow trenches of these tile pipes were carefully filled in with 1½-in. broken stone, insuring thereby the proper drainage of any ground water.

(2) **Compacting of Sub-soil.**—The sub-soil was carefully shaped and thoroughly rolled with a 15-ton roller until it was well compacted and its shape corresponded as closely as possible to that determined for the pavement

itself. Special attention was given to freshly opened cuts, and quite a number of the old ones were also thoroughly rolled. We observed that many of these old cuts settled down considerably under the roller, demonstrating the necessity of this rolling before the construction of any type of pavement.

(3) **Concrete Foundations.**—A concrete foundation was then laid to a depth of 6 ins. at least, the following proportions being used: one of cement, two and one-half of sand, and five of stone. Reinforcing rods 1 in. by 12 ft., spaced 12 inches apart, were laid in the concrete over all freshly made cuts as a precautionary measure in case of further settlement. Twice a day, this concrete foundation was thoroughly watered, and no traffic whatever was allowed over it.

(4) **Cushion Layer** (now more appropriately called the bedding course).—When the concrete foundation had properly set, two guide timbers, 1½ ins. thick by 4 ins. wide, were laid directly on the concrete, one on the curb line and parallel to it, and the other along the rail, then the sand and cement cushion, which had previously been mixed dry, in the proportions of one of sand to four of cement, was spread evenly over the concrete foundation to a depth of about 2 inches. A heavy templet having the exact cross-section of the finished roadway was then drawn over this on the wooden rails levelling down the cushion and compacting it to a thickness of about 1¾ inches. This operation was carried on in stretches of about 20 to 30 feet in length; when found necessary, more of the cement and sand cushion was distributed and the templet drawn over again until an even surface was obtained. Then, a hand roller weighing about 250 pounds was rolled up and down over the cushion until it was thoroughly compacted. After this the templet was again put in use, but this time the ¼-in. iron shoes at each end were removed, thus allowing the templet to shape and compact the cushion to a thickness of 1½ ins. When these operations were completed, the wooden guide timbers were removed and the cushion materials placed and compacted in the depressions they had occupied. The importance of properly shaping the sand cushion will be readily seen, as the final shape of the pavement depends entirely upon its success. The addition of cement in the cushion adds but very little to the final cost of the full work, and affords a stable foundation for the bricks, which cannot be disturbed by any cause.

It affords me great pleasure to bring to the attention of this convention the details of the construction of a new bedding course described above, and which is being rapidly adopted by quite a number of leading engineers in the United States.

I am also pleased to state that Outremont is probably one of the first cities in Canada, if not the first one, to adopt this new type of construction.

It is well recognized to-day that many failures in brick pavements can be traced to the non-uniformity of the sand cushion or the lack of proper compactness of same. It is claimed by some that a brick pavement should have a cushion so as to keep its resiliency under heavy traffic. It is very doubtful in my mind if the sand contained between concrete foundations and the brick pavement has really any elasticity, and my opinion is that this plain sand cushion can shift or be compacted by heavy traffic, and that the brick pavement itself may spring somewhat under this heavy traffic, but the sand cushion will not follow and small air spaces between the sand and the brick pavement may be formed, introducing weak spots which may cause serious trouble later. It has also been claimed that the sand cushion prevents the crushing of the brick pavement under heavy traffic. This idea, in my mind, is not well founded. If bricks well grouted are not able to sustain the load of modern pavement, the sooner they are discarded as paving materials, the better it will be.

The advantages now claimed in using a cement and sand bedding are as follows,—

Elimination of the hazard of the sand cushion during construction, as the pavement will not be injured at any time by rain, the wearing surface, with the exception of the filler, being completed each day. If a rainstorm intervenes, no damage is done, as there is no sand to become saturated and cause worry about rolling the brick surface.

Each brick in the wearing surface will be assured a cement bond its entire depth, for if the cement sand should work up in the joints, it will set up and prevent the shearing action which tends to crush the top of the brick.

There is no chance for the bed to shrink or shift away from the bottom of the brick wearing surface, as the brick is firmly bedded in the cement sand or held in the mortar of the concrete base.

Where these pavements have been laid there seems to be a total absence of any rumble under traffic.

Slight settlements and breaking of bond due to non-uniformity of sand cushion are eliminated.

One striking example of grouted brick pavements laid on cement sand bedding can well be described here, and that is the approaches to the Pennsylvania Railroad terminal in New York City, paved in 1910, the bricks being laid on a sand and cement bedding course mixed one to three. This pavement shows no signs of deterioration except along the curbs where the wheels of the heavily loaded wagons skidding down the inclines have cut somewhat into the bricks. The traffic on these approaches, it must be remembered, is very heavy.

(5) **Laying of Bricks.**—The bricks, which had been neatly piled on the sidewalk edge or at any convenient points, were carried to the droppers or pavers on wooden pallets, five at a time, and placed behind them in piles, five bricks high, and in such position that each brick could be handled so as to bring its lugs always in the same direction with its best edge up. The droppers, on dropping the bricks down in place, could proceed with their work by standing on the newly laid bricks and dropping the bricks ahead with the lugs away from them on the sand cushion. The brick joints were broken at least three inches, and nothing but whole bricks were used, except in starting and finishing courses. Every fourth or fifth course it was found necessary to straighten up or close up the courses. This was done by tapping them lightly with a sledge, using a 4-in. by 4-in. timber 3 or 4 feet long. At all times the bricks were clean and entirely free from chips, dirt or other foreign matter.

(6) **Rolling.**—After a certain stretch of bricks had been laid, and the surface thoroughly swept, a small 3-ton steam roller was used to roll them down. This was done in the following manner: The rolling was commenced near the curb at a slow pace and continued back and forth up to the rail, then the operation was repeated at a quicker pace. Next the rolling was done transversely at an angle of 45 degrees with the axes of the pavement, and then repeated in the opposite direction; then the bricks were rolled again parallel to the curb lines. During rolling the bricks were carefully inspected and all broken or chipped ones were immediately removed and replaced. Those bricks having settled too much, as well as those sticking up, were removed and replaced by other ones. The rolling operation was really a very attractive one to watch

as the smoothing out of the brick surface was very noticeable after the first trip of the roller. The rolling of all the bricks laid in one day was completed every night, so that if the weather became rainy there was no chance of the cushion setting before the bricks had been properly rolled. It is needless to say that we did not mix any more cushion materials than was required for one day's work.

(7) **Cement Grouting.**—The grouting was done as soon as possible after the bricks had been rolled down. These bricks were first thoroughly sprinkled, with the double object of supplying enough water to the cushion for setting purposes, and the thorough wetting of the bricks themselves. The sand and cement of the grouting were mixed dry in equal proportion, one to one, and to a uniform color. Batches of about two cubic feet were placed in specially constructed portable mixing boxes, having one corner lower than the others, the water being added very slowly and the mass thoroughly mixed with a hose until its consistency was liquid enough to allow it to flow without separation of the ingredients. This grout was then poured on the bricks with large scoop shovels and spread well into the joints with hand-squeegees, and the operation gone over until the joints were completely filled. The grout was always sufficiently fluid to thoroughly fill the lower part of all joints and flow several joints ahead of the squeegees, oozing up to the surface as more grout was pushed ahead. I am perfectly sure that every joint was filled up with the grouting from top to bottom, and that none of the cushion material partly filled the joints.

Fig. 2.—Applying Cement Grout Filler at Outremont, P.Q.

(8) After the grouting operations were finished, the pavement was well covered with tarpaulins or cement bags, and kept moist for several days, thus insuring the slow settling of the grout.

(9) Vehicular and pedestrian traffic was kept off the freshly made pavement for a period of at least fifteen days, according to the weather and temperature. When pedestrian traffic had to cross a section of the freshly made pavement, a thick layer of sand was spread over it and heavy planks laid over this sand; so, in no manner did the pavement receive directly any traffic.

(10) I personally gave this considerable attention, and aided by my assistants, every detail of the work was carefully supervised. No highway engineer can expect to have good results on brick pavement without the most minute supervision of every detail of the construction.

The bricks specified for this pavement were of the type known as the "Wire Cut Lug Brick." The main advantages in using these bricks are that the joints are all uniform in width on account of the presence of the lugs which maintain the bricks at an equal distance from one another, and also the fact that the bricks have square corners, and that the joints can be filled from top to bottom at an uniform width without any danger of the grouting being chipped at the surface, as in the case of bricks with chamfer corners. These bricks had to comply with the general clauses adopted by the American Society of Municipal Improvements.

The wire cut lug bricks that were used were tested as follows:—

Abrasion test averaged thin blocks: At 600 revolutions, 8.55%; at 1,200 revolutions, 12.00%; at 1,800 revolutions, 14.21%.

Absorption test: 1.21%.

In conclusion, I must state that the advantages of brick roadways are as follows:—

(1) When properly constructed with the right materials, they will wear smooth without being slippery.

(2) They are the most sanitary pavements known, being easily cleaned and absolutely dust-proof.

(3) They are practically noiseless.

(4) They are economic in the long run as they require very little attention and maintenance.

(5) They can be cut through when required and easily repaired at small cost without any cumbersome plant.

Charcoal is almost an ideal furnace fuel. It is nearly free from sulphur, having only a few hundredths of 1 per cent. in coke and about 1 per cent. of ash against about 10 per cent for coke.

There is a remarkable tendency observable in tissues and cotton when moistened with oil, to become heated when oxidation sets in, and sad results often follow when the tendency to take fire is neglected. A wad of cotton used for rubbing a painting has been known to take fire when thrown through the air. The waste from vulcanized rubber, when thrown in a damp condition into a pile takes fire spontaneously. Masses of coal stored in yards frequently take fire from spontaneous combustion without any spark of fire being applied to the mass. It is good to know such things and to guard against mysterious fires.

In an action against a railroad it appeared that the plaintiff was walking on a parallel track used by another road and upon the ends of the ties next to the defendants track, about 5½ feet from the ends of the ties on the defendant's track, when he was overtaken and run over by a heavy freight train drawn by two engines on an upgrade and a partial curve. The train, which had stopped for water at a tank about 485 feet back, was running from 3 to 25 miles an hour. The plaintiff testified that he was drawn under one of the cars by the suction caused by the speed of the train, and his leg smashed. There was evidence that no suction could have been produced at the speed the train was going, and that even at a greater speed than 30 miles an hour, trains had frequently passed close to section hands repairing the track without any such effect being produced; also that the effect produced by a rapidly moving train would be merely to split the air and drive objects away from it, such as dust from the track and hats from the heads of men standing near it, the force of the wind being away from the train rather than towards it. The jury returned a verdict for the plaintiff, which the trial court set aside, for the reason that there was no evidence to support it, and entered a judgment of non-suit. On appeal this was affirmed by the North Carolina Supreme Court in an exhaustive opinion. The court held that the plaintiff's injury, if occurring as the result of suction created by the rapidly moving train, was an unusual occurrence such as the engineer could not have reasonably expected would result from the rapid movement of the train, and hence such movement was not negligence.

COAST TO COAST

Montreal, Que.—The government has authorized a small advance to provide for the continuance of the work on the harbor.

Montreal, Que.—At a meeting of the Chamber of Commerce the question of raising the Grand Trunk tracks was taken up.

Edmonton, Alta.—The Oliver, St. Paul de Metis Railway, according to Sir William Mackenzie, will be in operation before the end of June.

Trenton, Ont.—The steelwork on the new bridge over the Trent River is almost completed. The structure is expected to be ready for traffic very soon.

Montreal, Que.—Plans have been submitted to the Board of Control for a tunnel estimated to cost $1,200,000 under the Lachine Canal at Wellington Bridge.

Owen Sound, Ont.—The secretary of the board of trade announces that engineers will soon commence surveys on the harbor for dredging purposes.

Toronto, Ont.—A trial trip has been made over the newly-electrified Schomberg division of the Metropolitan Railway. A regular service will be inaugurated shortly.

New Westminster, B.C.—The annual report of City Engineer J. W. B. Blackmore shows that the work carried out under the supervision of his department cost $371,020 for 1915.

Toronto, Ont.—It is learned that the government's bill on hydro-electric development at Niagara Falls will provide for an ultimate expenditure of $14,000,000 to be supplied as the work proceeds.

St. John, N.B.—Engineers of the Canadian government are engaged in locating a new line from near Fredericton across York county to connect with the Maine Central Railway at Vanceboro', Me.

Toronto, Ont.—The foundations on the new Union Station are being rushed ahead in order to be ready for steel erection. It is expected that the steel construction work will commence about April 10.

Montreal, Que.—Pavement was laid on 45 miles of streets in the city last year. The total cost of the work was $1,934,408. Asphalt for the most part was used as surfacing, the total quantity being 7,145 tons.

Hamilton, Ont.—Arrangements have been made with the Dominion Power and Transmission Company by which the hydro radials will run over the tracks of the Hamilton Street Railway on their route through the city.

Victoria, B.C.—Legislation will be introduced within the next ten days looking towards the aiding of shipbuilding to the extent of a sum not exceeding $2,000,000 by way of guarantee. It is planned to lay down ten ships at once.

Brantford, Ont.—The city has been granted the right to operate the Grand Valley Railway under the name of the Brantford Municipal Railway System. The line runs from Brantford to Galt through Paris and Dumfries.

Victoria, B.C.—At a meeting of the reorganized Canadian Puget Sound Lumber Company it was decided to begin operations at the Victoria Mill and Jordan River timber limits at once. Five lumber-carrying ships will be built by the company.

Hamilton, Ont.—Mayor Walters advised the Board of Control to postpone until after the war the question of an entrance into Hamilton for the Toronto-Hamilton Highway, unless a satisfactory agreement could be made with the Commission.

Toronto, Ont.—The provincial government has purchased the Seymour interests in Central Ontario, comprising over twenty companies. This will give the hydro-electric commission complete control of power in the province. The price paid was $8,350,000.

Sarnia, Ont.—Engineer J. J. Jeffreys, of the Ontario Hydro-Electric Commission, advises that when Sarnia installs a street lighting system a good set should be put up. The system suggested by Mr. Jeffreys would cost $12,000 a year, in place of the present $7,000 a year.

Fort William, Ont.—A proposal for the government railway to link up to the Canadian Northern Railway and run over the latter's line from Fort William to a point north of Long Lake is on foot. Such a line would put Fort William 215 miles closer to the new gold camp at Kow Kash.

Fort William, Ont.—The inter-cities committee of Port Arthur and Fort William passed a resolution recommending that the two city utilities committees get together to frame up a proposal to get the hydro-electric commission to expropriate and operate the Kaministiquia power plant or allow development at Nipigon or Dog Lake.

Ingersoll, Ont.—That it is the intention of the gas company to furnish Ingersoll with purified natural gas was the welcome news received recently. A representative of the company was in Ingersoll and conferred with the special committee of the council appointed recently to deal with the situation in consequence of the purifier at the gas plant having been destroyed by the recent explosion and fire.

Winnipeg, Man.—Dredging an 18-foot channel in the Assiniboine River, from its junction with the Red to Assiniboine Park, is a feasible plan, City Engineer Brereton said recently, and the Board of Contral seemed to favor approaching Hon. Robert Rogers to see if the Dominion Government would not do this work. The purpose of the channel would be to make motor boating to the park possible.

The Pas, Man.—That the Hudson Bay Railway will be completed in time for the 1917 crop shipment is the belief of builders here. The summer construction programme concludes plans to have the steel track laid to Kettle Rapids, 90 miles from Hudson Bay, by August 1st. Construction of the cantilever bridge over the Nelson River at this point is expected to be finished in time to allow further steel-laying before frosts set in.

Calgary, Alta.—A decision of the Supreme Court affecting farmers on the Canadian Pacific irrigation block has just been handed down by the Supreme Court, in which the court dismisses the action by the farmers, in which the latter claimed that the contracts with the railway company were made under misrepresentation, in that irrigation has been a detriment in some sections of the irrigation belt, and alleging other reasons for their request for the annulling of the contracts.

Editorial

HARNESSING THE TIDES.

In an address before the Commercial Club of Halifax recently a scheme to harness the Bay of Fundy tides for the development of hydro-electric power was outlined by Dr. Geo. B. Cutter, president of Acadia University. The scheme, which has been worked out by Dr. Cutter, in conjunction with Prof. R. P. Clarkson and Ivan Curry, has been often talked of, and should give a supply of power which would be cheap and practically unlimited.

The proposal is to place strong current motors at the base of Cape Split by which power would be generated to elevate sea water to reservoirs, which would be built on the top of the cliffs. The water would then be conducted to the power-house at the base of the cliff and returned to the sea. On examining the tidal flow in the Bay of Fundy a remarkable variation was found, the rate in the middle of the Bay being between one and two knots. The maximum at Digby Gut is four knots, and the highest rate is in Minas Channel, where the flow is between eight and ten knots, or between nine and eleven miles per hour. This rate of flow is greater than the swiftest streams, and is equalled by tidal current at only two other spots on earth. For this reason Minas Channel is the most favorable location for the development. Difficulties of developing tidal power are due to the unevenness of flow, necessitating storage of some kind to keep the output of power uniform. Also, power schemes must not interfere with navigation.

The power plant suited to even such a favorable tide as the Bay of Fundy must be so adjusted as to give continuous, regular and sufficient power, with low cost of installation and operation, and at the same time not interfere with navigation.

The site chosen as the most suitable for reservoir is at Cape Split, where the perpendicular cliffs rise over 300 feet. The greatest problem of the development is to get the water up on top of these cliffs. The scheme proposed to accomplish this is to install specially designed current motors at the foot of the cliff. These motors would supply power to operate pumps, which would elevate the sea water to reservoirs placed on top of the cliff. The water would then be delivered to the power-house at the base of the cliffs. By this method the flow from the reservoir would be continuous and regular whether the pumps were operating or not.

The motor designed for the work has already been constructed in the form of a model, which develops 27 horse-power, and is so light as to be carried by two men. As the motor is very simple in design, the cost of installation and operation will be very low. Multiple units will be arranged, both for motors and reservoir, so that in case of one unit breaking down there will be another ready to step into the breach. As a central distribution point Cape Split could not be surpassed. Within a radius of 125 miles are Antigonish, Yarmouth, Fredericton, Newcastle, and most of Prince Edward Island. Transmission lines of about 85 miles each would reach Digby, New Glasgow, Moncton and Halifax. In comparison with Ontario, where power is transmitted 250 miles, these distances seem short. This would be a very valuable acquisition to the Maritime Provinces, whose development, industrially, would be assured. At present the total available water power is 34,500 horse-power, while this scheme would make possible a development of 2,000,000 horse-power.

SPRING CLEAN-UP FOR THE RAILROADS.

For the next few months the section gangs of our railroads will have their hands fully occupied in repairing and rehabilitating the various sections of roadbed under their supervision which have been more or less temporarily ballasted, or on which the rails have been brought to even grade with wood shims during the winter season, which is now nearly over.

If it were possible to do this work during the winter a great amount of labor could be saved which could be put to trimming slopes, planting grass on sides of earth-cuts, and doing other work which would be preparing the line for summer traffic. As it is, the work now is crowded, so that it is almost impossible to do anything toward making the line attractive from the viewpoint of the travelling public.

To the engineer, a well-prepared roadbed has certain qualities which do not present themselves to the layman, who has come to look upon the track and roadbed more as something which mars the natural beauty of the landscape.

If it were practicable, and there is no real reason why it should not be so, to employ extra men in such numbers that the whole line of roadbed and everything adjacent should be given a sort of spring cleaning—new sodding done, nicely-moulded shoulders put on the grades, gardens at all station grounds, and lots of fresh paint and whitewash, it would without doubt repay the railroads, inasmuch as it would make travelling much more pleasurable. If this were more generally done in the spring, the period of usefulness of the passenger to the railroad, and incidentally to the "monthly railroad earnings," will not have lapsed; on the contrary, it will perhaps have increased when his journey is over and he has elbowed his way through the crowded station once more. For while travelling over the road he has been the sightseer, awed with the grandeur of the scenery presented to his gaze in an endless panorama of natural beauty. We say natural beauty advisedly, because it is only nature's work that he sees, while the hand of man is hidden by careful landscape work, or at least it is unobtrusive, and does not seem to mar the natural scenery so much as when it is left as the construction gangs left it, showing the hand of man as a ruthless destroyer. It is after the trip that the tourist does his best work for the railroads in that he tells his friends of the beauties of the various railroads over which he has travelled. Again, if the tourist has been over a road that has not done any beautifying he will loudly denounce it. The railroad will be a blotch on the landscape, and he will advertise it as such. It would not take so very much labor to make this road more presentable from a beauty standpoint. One cannot paint

the lily is a very true saying, but a little touch of white paint over any disfiguring marks will make it a great deal more presentable—at a distance, anyway, and that is how our tourists see things.

When the returned tourist talks is when his value to the railroads is at its highest. His friends may be just waiting to settle the much-discussed question of "where to go" when he tells of his travels. They probably only need a little encouragement in certain directions in order to make them decide.

Some work is done on the railroads in the spring, but it is generally of a utilitarian nature. It is usually summer before the efforts of trackmen and station agents are evident, at least to the travelling public.

ALTITUDES IN CANADA.

The Board of Railway Commissioners have taken a step in the right direction in their recent order, in which all railroad companies when submitting profiles of their roads or extensions, must base all elevations shown thereon to Mean Sea Level. This will apply to all lines, commencing, terminating or intersecting with any of the lines as listed in White's "Altitudes in Canada," a work which has been widely distributed. This will tend to spread the network covered by "Altitudes in Canada," and will be of inestimable use to engineers who will in the future be commencing some work from a point which is already listed in the book. The order also stipulates that any line touching tide water must show elevation above Mean Sea Level.

It would be of advantage to engineers if all works were carried on with a common datum, and it would be in our own interests to include not only railroads but any engineering work in the above order. Of course, we will still have to resort to the old stump B.M. We usually assume it to be elevation 100.00 in out-of-the-way places, but wherever possible we should carry on the elevation in respect to Mean Sea Level.

SASKATCHEWAN LAND SURVEYORS.

The officers of the Saskatchewan Land Surveyors' Association elected at the annual convention in Regina are: W. R. Reilley, Regina, president; R. W. E. Loucks, Regina, vice-president; H. G. Phillips, Regina, secretary-treasurer. Four councillors were elected as follows: W. M. Stewart, Saskatoon; E. W. Murray, Regina; W. Thompson, Grenfell; and F. Lamb, Saskatoon. P. W. Brown, of Saskatoon, and S. Young, of Regina, were appointed auditors.

PERSONAL.

E. E. FORGEUS has been appointed purchasing agent of the Eastern Car Co., New Glasgow, N.S.

T. V. McCARTHY, B.A.Sc., of the Waterworks Department, Toronto, has enlisted for overseas in the 43rd Howitzer Battery.

H. S. PHILLIPS, formerly chief draftsman in the Sewer Section, City Hall, Toronto, has accepted a similar position with the Canadian Nitro Products Company.

Lieut.-Col. CHARLES H. MITCHELL, C.E., M. Can.Soc.C.E., Toronto, has received from the French government the officer's cross of the Legion of Honor.

SAMUEL G. ALLEN has been elected president of the Franklin Railway Supply Company, and Mr. Joel S. Coffin, formerly president, is now chairman of the board.

J. E. RICHARDS, general auditor of the London and Port Stanley Railway, has been appointed manager and treasurer of the road, succeeding F. T. LEVERSUCH, who resigned. Mr. Richards was formerly with the Chatham, Wallaceburg and Lake Erie Electric Railway.

OBITUARY.

CHARLES H. CONERY, well known as a paving contractor, died last week in Guelph.

WM. NORRIS, manager of the Chatham, Wallaceburg and Lake Erie Electric Railway, died in St. Joseph's Hospital, London. He was fifty years old, and was formerly connected with the London Street Railway Company.

THOMAS TOMLINSON, head of the firm of Thomas Tomlinson & Son, iron founders, Frederick Street, Toronto, died on February 22 in the Western Hospital, following an accident. The deceased was 45 years of age.

MANITOBA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a meeting on March 6th of the General Section of the Manitoba Branch of the Canadian Society of Civil Engineers Messrs. W. G. Chace and M. V. Sauer gave an interesting review of the present and proposed hydroelectric development in the Niagara Falls district. The differences in the various plants were pointed out, special features were discussed, and the advances made in electric power transmission within the last twenty years were dealt with.

VANCOUVER BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

Detailed description of the government's great floating drydock at Prince Rupert, largest but one of all Canadian docks of a similar type, the Montreal construction being slightly more imposing was given by J. H. Pillsbury, of the engineering staff of the Grand Trunk Railway and engineer in charge of the construction of the northern dock, before the members of the Vancouver branch of the Canadian Society of Civil Engineers at their meeting in the Board of Trade rooms.

The dock has a lifting capacity of 20,000 tons, about the tonnage of a steamer of 650 feet. It is in three sections, each one capable of being sunk and lifted independently for the accommodation of smaller vessels. In connection with it there is a very complete plant, including light and power plant, machine shop and shipbuilding plant. The cost of the whole plant, dock and all, had been \$2,600,000, but the cost of the dock and its accessories was about \$800,000.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

ROAD IMPROVEMENT IN THE PROVINCE OF QUEBEC

SHOWING HOW THE EXPENDITURE ON ROAD CONSTRUCTION AND MAINTENANCE HAS INCREASED FROM THIRTY DOLLARS IN 1895-96 TO SIX MILLION DOLLARS IN 1914-15

IN the report of the Roads Department of the Province of Quebec the remarkable growth of the good roads movement since its inception is interestingly described. The development of each type of road is outlined in the following paragraphs abstracted from the Minister's Report, published a few weeks ago.

Earth Roads.—The maintenance of earth roads has been the object of the government's attention for over fifteen years. At the beginning of that period, although the advantages of hard surface roads were known, it was quite naturally thought that the most pressing matter should be attended to and the farmer be induced to keep the municipal road in order as it already was: that is, with its irregular shape, its more or less steep grades, its insufficient drainage and almost ever doubtful means of carrying off the water from its surface. The idea of improved roads was then so slightly developed, while traffic was so far from having the requirements of the present day, that one can understand why maintenance should be only temporary work, to meet the needs of limited wheel traffic and of trade whose rapid growth was not yet in the least suspected. Neither had the automobile then revolutionized transportation, in this country at least.

Fig. 1.—Montreal-Quebec Road, Donnacona (Portneuf). Macadam Done in 1915.

Our industry, our agriculture, our means of communication all were nevertheless destined to soon undergo a transformation. On the eve of such transformation, bad roads, while an immense obstacle to progress and an unexplainable economic error, were tolerated by the mass of the population. On the morrow, a change became necessary; without insisting at once upon having macadamized roads, public opinion called for properly kept roads or, at least, if it did not manifest itself openly, they whose business it is to know public opinion, to listen to it, to interpret it and, at times, to forestall it and satisfy its just aspirations, did not fail in their duty and, with praiseworthy foresight, they laid the basis of a regenerative movement which has not ceased to grow since then.

In a country of such inexhaustible resources and such prospects for the future as Quebec, earth roads are destined to become gravel or macadamized roads or roads treated with bitumen or paved with concrete. This means that when traffic with vehicles drawn by animals, later with automobiles and motor trucks, becomes greater, then earth roads will become insufficient and will have to be gradually replaced by the surfaces just mentioned or by other equivalent or better ones.

With these facts in view, the following conditions were imposed on municipalities who received grants for road maintenance from the government, the object being to make the work done serve for future developments. These consist: (*a*) in lowering the hills to a grade of 6 per 100 feet, or in going around them; (*b*) in re-making the ditches and giving them a regular slope of at least 5 inches per 100 feet; (*c*) properly draining damp and low spots; (*d*) straightening too-sharp bends; (*e*) to removing all stones from the road and removing all rocks where its width is not sufficient; (*f*) properly rounding off the road for a length of one mile, taking care to not put more than a layer of four or five inches at a time and to pack it before running the machine over it again; (*g*) replacing the old wooden culverts by tile, concrete, corrugated iron, etc., ones.

The repairs mentioned do not represent all the permanent repairs that could be done, but it was thought advisable not to overload the programme. The municipal councils in charge of the work acted on the conditions and not only fulfilled them but did more. They widened roads not included in the programme; improved longer stretches of road than required, and made various other improve-

ments. All this was done at a cost less than previously, even though the various councils had decided to do the work regardless of the poor state of financial affairs. This shows the friendly attitude of the public toward the good roads movement in the province of Quebec.

Gravelling.—Without overlooking the remarks just made respecting the gradual substitution of hard surfaces for earth, it may be said that the gravel road is destined to render great services. When well made, its surface is as suitable for automobiles as for vehicles with metal tires and there is no reason why it should not be used instead of macadam, especially on account of its comparatively small cost. Gravel costs about one-third and sometimes one-fourth the price of macadam. In connection with gravelling, there are some principal points to be considered: the distance over which it must be carted and the quality of the gravel. For a distance of one or even two miles—if it cannot be done otherwise—carting gravel is inexpensive, especially when the gravel is of superior quality. Some gravels possess cohesiveness, require no rolling nor sprinkling, are compressed by the sole weight of the traffic (provided it be always followed by running the double drag over the road), and their use does away at once with a rather considerable expenditure. On the

Fig. 2.—Edward VII. Road, Parish of Napierville. (Upper) Laying Gravel on Fluxphalte. (Lower) Finished Road.

other hand, the same gravels have in most instances, a co-efficient of hardness lower than that of less earthy gravels. The latter are harder, but have less cohesiveness and this defect must be overcome by rolling and sprinkling, although, properly speaking, the most economical method and that generally followed calls for neither rolling nor sprinkling. Good gravel which binds well and which lies at a normal distance should evidently be used in preference to a harder gravel lying too far from the spot where it is to be used. Only in the case of bitumen gravelling is it advisable to use gravel not sufficiently hard, even if found close by. The principle on which this theory is based is that it would be unwise to use capital for an improvement most of which would not be permanent. Although the gravel surface wears out as the earth one does, and as also does a stone surface, if the road, when gravelled, is properly kept, a very considerable portion of the gravel remains and serves as a foundation, as it were, for fresh layers of gravel.

Gravel which does not contain more than 20% of earthy substances cannot be accepted for normal gravelling. In such cases, the use of stone covered with such gravel is recommended. Specifications are never drawn up before the gravel is examined in the laboratory. The engineers also make a study of haulage distances and organization of labor for the benefit of the municipalities.

Fig. 3.—Montreal-Quebec Road—St. Paul-l'Ermite (L'Assomption). Macadam Done in 1915.

In the course of his report, the Hon. M. Tessier says: "Another thing to be considered in studying the the most economical methods of construction, is the extraordinary development of our road policy. At an interview which I recently had with the members of a very important delegation, it was observed to me that the carrying out of that policy had upset everything, had completely changed the ideas of the rural population, had done away with all opposition to the new state of things we had created; that we no longer needed to have lectures given, to carry on a campaign; that the province now came to us, begged us to not stop, even asked us to set aside the precautions which the present financial situation imposes on us. Such dispositions on the ratepayers' part should not displease us, for we really have wished for such mentality, have brought it about and we wish to maintain and even develop it if necessary. But, as we said at the beginning of last season, we must continue on a reasonable upward path that is in proportion to the resources of the province, in accordance with the march of events. At this moment, our political life, or at least our financial life, is bound up with the financial life of the whole world. That means the obligation under which we are placed to not arrest the impetus that has been given to seek the more easily accessible means to meet first needs for a certain

Fig. 4.—Levis-Jackman Road—St. Georges (Beauce). Conveying Gravel with a Traction Engine and Trucks.

time. We have not failed in it; after deciding, last spring to spend a certain amount, we set to work and divided up that amount in the most rational and equitable manner possible. After several weeks of arduous labor, we succeeded in starting work again throughout the province

and, considering the late date at which we began, it will be seen that, notwithstanding the financial crisis, the many difficulties due to rectifying estimates and applying such rectified estimates, the amount of work done is not only not less, but is greater, all proportions considered, than the amount of work previously done. The total length of roads made with gravel or stone by municipalities last season was 97.68 miles.

Macadam.—As in 1914, the province was divided into districts for the purpose of inspecting the macadam in course of construction. The supervision of such important and costly work is one of the things whose organization we have most at heart. We strive to improve it from day to day and to get the maximum of efficiency from each inspector.

As is indicated in the instructions issued to inspectors, they are expected to teach the instructors how to make macadam and how to handle the road gangs. They are instructed to see that specifications are followed precisely as intended. He is a road maker and should work with the instructor.

Inspections are made in sections of 200 feet, which are staked out beforehand. Width of road, thickness of foundation and number of layers of stone are noted. Drainage facilities are inspected with a view as to whether the slope of watercourses in culverts and under bridges is correct.

The important roads which are being macadamized are: The Montreal-Quebec Road, the Levis-Jackman Road; the Sherbrooke-Derby Line Road, the Chambly Road, King Edward VII. Road, and many smaller roads. The following figures will show the mileages of roads built in 1915 and the money expended: 295.60 miles of macadamized roads (municipal and provincial) were made in the province under the direction and with the aid of the government; 140.70 miles of gravel roads (municipal and provincial) were made under the direction and with the aid of the government.

Since 1911, 1,173.10 miles of macadamized roads and 494.57 miles of gravel roads (being 1,667.67 miles of roads permanently improved) were made in the province under government control.

Since 1911, the government of the province has paid for the maintenance and improvement of earth roads, as well as for making macadamized and gravel roads and for the expenses of administration of the Roads Department, $14,584,681.12.

The following statement of sums spent during the last 20 years by the Quebec government for road improvements shows the astonishing rate at which the good roads movement has grown in that province:

Year.		Year.	
1895-96 ....$	30.20	1905-06 ....$	9,661.88
1896-97	5,953.34	1906-07	15,404.56
1897-98	7,795.56	1907-08	20,117.85
1898-99	10,203.29	1908-09	60,146.92
1899-00	14,510.00	1909-10	60,000.00
1900-01	13,000.00	1910-11	95,000.00
1901-02	6,000.00	1911-12	494,277.06
1902-03	17,572.79	1912-13	1,069,810.35
1903-04	11,000.00	1913-14	4,018,916.68
1904-05 ...	18,250.58	1914-15 ...	6,140,273.13

There is an excellent demand for magnesite for furnace linings. In Quebec several properties are being operated, and it is to be hoped that the industry will become well established while the demand is so good.

MAKING BOTTOM FOR PILES BEFORE DRIVING.

It is quite common practice to deposit filling of some suitable material between and around the piles of a pier both to increase the resistance of the structure as a whole to lateral displacement and to increase the columnar strength of the piles themselves by decreasing their unsupported length, and also, but to a less extent, increasing their bearing power by additional skin friction. Care must be taken while depositing the fill to bring it up uniformly, so that the lateral pressure on the piles as units may be equal on all sides. A concentration of material at one point is capable of disastrous results, *viz.*, springing the piles out from under the caps or bowing the piles, with a consequent eccentricity of load, or even shearing off the piles near the mud line. Nevertheless, the fill is usually heaped up along the axis of the pier, sloping both ways from the centre line, giving the structure a "backbone," as it were. Sand, gravel, broken stone, or rip-rap is the usual fill material.

This method of filling is described by F. L. Simon in the Journal of the Engineers' Club of Baltimore, who says that while it has been employed successfully many times, yet it has the decided disadvantage of difficulty in controlling the distribution of the fill, resulting in one notable instance in the collapse of the structure. Why not, then, make the fill before starting the construction? The difficulty of controlling the distribution still obtains, but—and herein lies the great advantage of this method—strict uniformity of distribution is not essential and the entire hazard of the first method is obviated. There are no lateral pressures on the piles, indeterminate in amount and direction, as in the previous method, and no tendency toward a settlement of the piles with that of the fill. Secondly, there is the advantage of economy, due to the fact that shorter piles may very often be used because of the increased skin friction of the fill and compressed mud beneath it, giving equal or better test penetrations than in the first method, and due also to the relative ease of depositing the fill from scows previous to the erection of the pier.

The superiority of this second method was ably demonstrated during the construction of a pier 62 ft. wide by 830 ft. long. A number of test piles driven over the area of the pier revealed unusually severe bottom conditions—18 to 20 ft. of water and 45 to 60 ft. of mud overlying sand and clay—from which it was obvious that a large percentage of the piles would have to be in lengths of 85 to 95 ft., and most of them spliced. Fears were entertained, too, for the ability of a pier in such bottom and of such scant width to resist lateral thrusts, even though properly braced with batter piles. The safety of the assumed safe load per pile used in calculating the design was questioned.

It was suggested, therefore, that a bottom be "made" before driving the piles by dumping heavy material from bottom-dump scows over the area of the pier. The plan was approved and the bottom deposited. The material used was mixed sand and gravel, dredged from the river, weighing about 2,800 to 2,900 lbs. per cubic yard. The river mud appeared to absorb the fill; it was compressed rather than displaced, although there was a slight upheaval on both sides of the deposit and some shoaling of the water over the deposit. Piles generally 10 ft. shorter than originally contemplated were driven to satisfactory final penetrations. Not one spliced pile was used. The fill served the additional purpose of staying the piles at the mud line and stiffening the structure laterally.

EXAMPLES OF CONSTANT ANGLE ARCH DAMS.

In *The Canadian Engineer* for March 9th, 1916, were outlined the chief points in the design of the constant angle arch dam, wherein, it will be remembered, a considerable saving of masonry may often be effected The following descriptions by the author, Mr. L. R. Jorgensen, by whom the design of this type has been developed, relate to two important installations of this type. The attention of our readers is called to mention of these structures by Messrs. A. P. Davis and D. C. Henry in the article on Masonry Dams which appeared in our issue for January 27th.

Lake Spaulding Dam.—This dam is located on the South Yuba River, near Emigrant Gap, Cal., and is owned by the P. G. & E. Co. The distance from the Southern rock was conveyed from under the storage bins to the top of the mixing house by means of belt conveyers, and from here distributed into measuring hoppers. The cement was brought in by a belt conveyer from the storage house and the mixing of the gravel and cement was done on the second floor of the mixer house. On the first floor of the mixing house were four 1-yard mixers driven by electric motors. Stretched across the canyon above the dam were two cableways each having a span of 1,400 ft. The cables were 2 in. in diameter with a breaking strength of 170 tons. The operating cabins contained a variable speed hoist and traversing line, centrally operated by a 112-h.p. induction motor. These cableways handled all material except concrete.

The concrete from the mixers was transported to the dam by gravity in a 30 in. wide by 12 in. high wooden

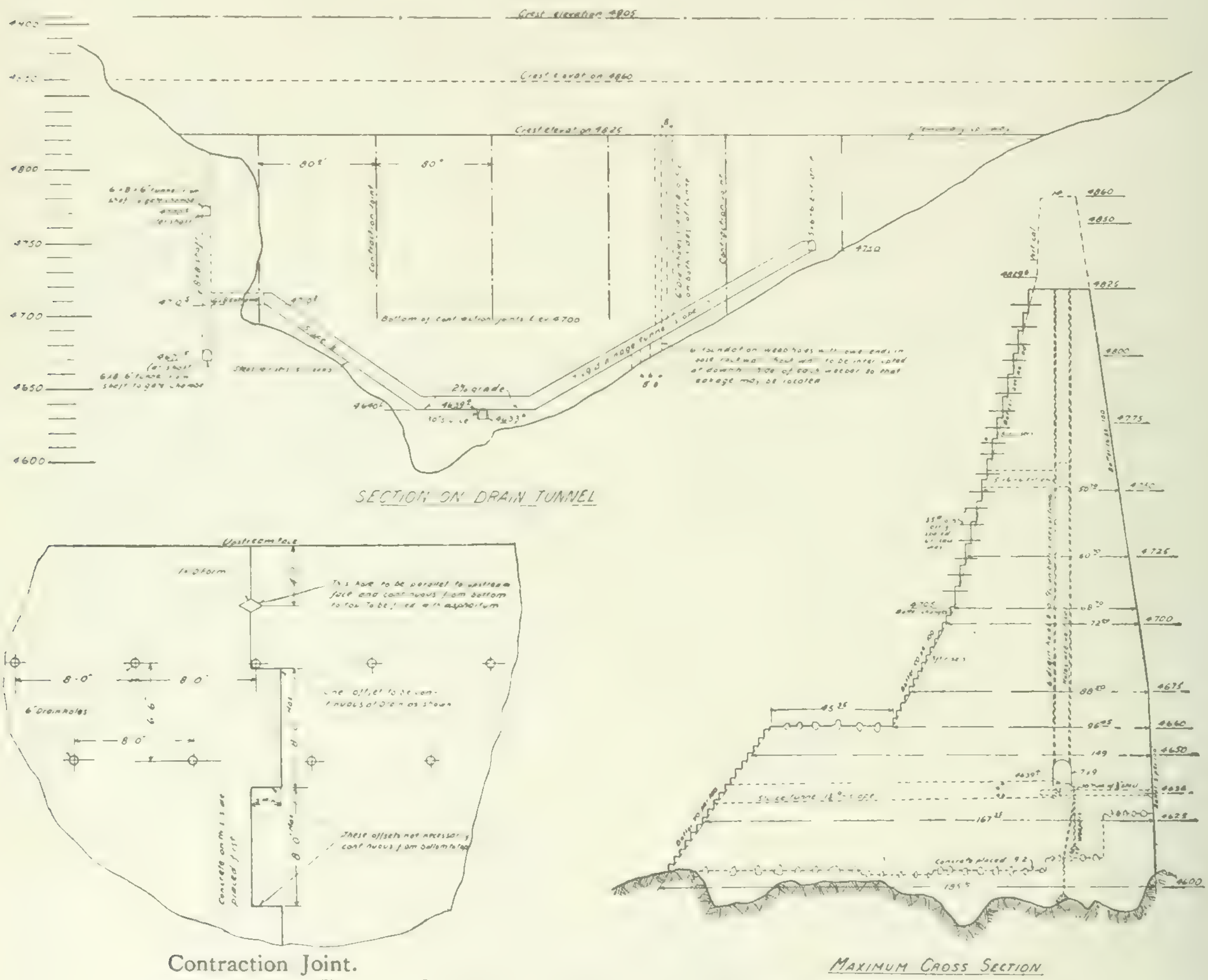

Fig. 1.—Sections of 225-foot Lake Spaulding Dam.

Pacific Co.'s railroad at Smart to the dam site is only 2.3 miles. Over this distance the company themselves built a standard gauge track to facilitate the transportation of material and men. The track terminated at the works plant elevated somewhere above the crest of the dam. The works consisted of a compressor house, a mixing plant, storage bins for crushed rock and gravel, and two rock crushers. It was possible to place the crushed rock in the bins or to dump sand and gravel from the cars in the bins as required. On the hillside below the bins was located the mixing house, built in four stories. Gravel or

flume, lined with 5/8-in. thick cast iron plates on the bottom. This flume had a slope of 1 : 3 down the hillside to a nearly vertical cliff at the south abutment. A tower was constructed below the cliff provided with short sections of chutes built as baffles, allowing the concrete to drop to the bottom of the tower, where it was discharged into a number of distributing chutes. When the crest of the dam had reached the top of the tower the concrete could no longer be distributed by gravity flow, and a series of 30-in. belt conveyers with a slope of 18° was installed along the top of the dam. The support for these

conveyers was made of steel and left in place, jets of compressed air swept the belts clean of concrete at points of discharge. Fifty thousand yards of concrete was handled in this manner.

The material of which the dam has been built was subject to much study and experimentation before being used. There was discovered several sand deposits within a short distance of the dam, but this sand contained a certain amount of silt, so that washing would have been necessary and the amount of sand required could not have been furnished fast enough to maintain the progress decided upon. A source of supply in the Bear River, near Colfax, about 60 miles away, was chosen as the best one available for the purpose. Here the material was in the form of gravel and sand in proportion very close to the desired mixture. The Lake Spaulding dam is therefore largely constructed of the quartz, gravel and sand from the Bear River, with but a small proportion of other gravel and rock, necessary to mix in at times when the bank run of the natural gravel deviated the desired proportion. Throughout the work, samples of green concrete were taken from the dam after concrete had been deposited, these samples being obtained at various points in the dam. Enough samples were taken every day to supply three for a 7-day test, one for a 28-day test, one for a 60-day, one for a 90-day and one for a 5-year test. Each day the test samples, as their time became due, were broken, and very complete records were made on each to determine the condition of the mix and to make any corrections necessary.

The average minimum crushing strength per square inch was about as follows: 7-day specimens, 400 lbs.; 28-day, 900 lbs.; 60-day, 1,000 lbs. or more. The ultimate strength should considerably exceed these amounts. The proportion of the mix generally used for the lower portion was 1 part of cement, 2½ of sand, and 4½ of gravel. Towards the crest the mix was made richer, about 1:6, using up to 1¼ barrels of cement per cubic yard. A wet mix was used, which was turned for 1½ minutes in the mixers before being discharged into the gravity flume. By experimenting, it was found that 1½ minutes was the minimum time to thoroughly mix a batch, so as to ascertain maximum compressive strength.

Design.—It was first proposed to build a gravity dam, arched in plan, having an upstream radius 600 ft. long. Such a structure was started in 1912 and during that year reached an elevation 28 ft. above the river bed at the upstream face and less at the downstream face, as shown on Fig. 1. During the winter the original plans were changed and the construction of the dam continued the following summer in accordance with design shown on Figs. 1 and 2. At Elev. 4,628 the length of the upstream radius was changed to 250 ft. and kept at this length up to Elev. 4,675. Up to this elevation the canyon is very narrow compared with the thickness of the arch and the curved beam and wedge action will therefore predominate over the arch action. From Elev. 4,675 up to the crest, the length of the upstream radius increases so as to keep the subtended central angle as constant as possible, as shown by the table in Fig. 2. This subtended angle is not as large as could be desired, but is as great as the site would permit, considering that the ultimate proposed crest elevation is to be at Elev. 4,905, and considering that this type of dam had to be built on top of the other type already started. The proper place for the new type would have been about 100 ft. further upstream.

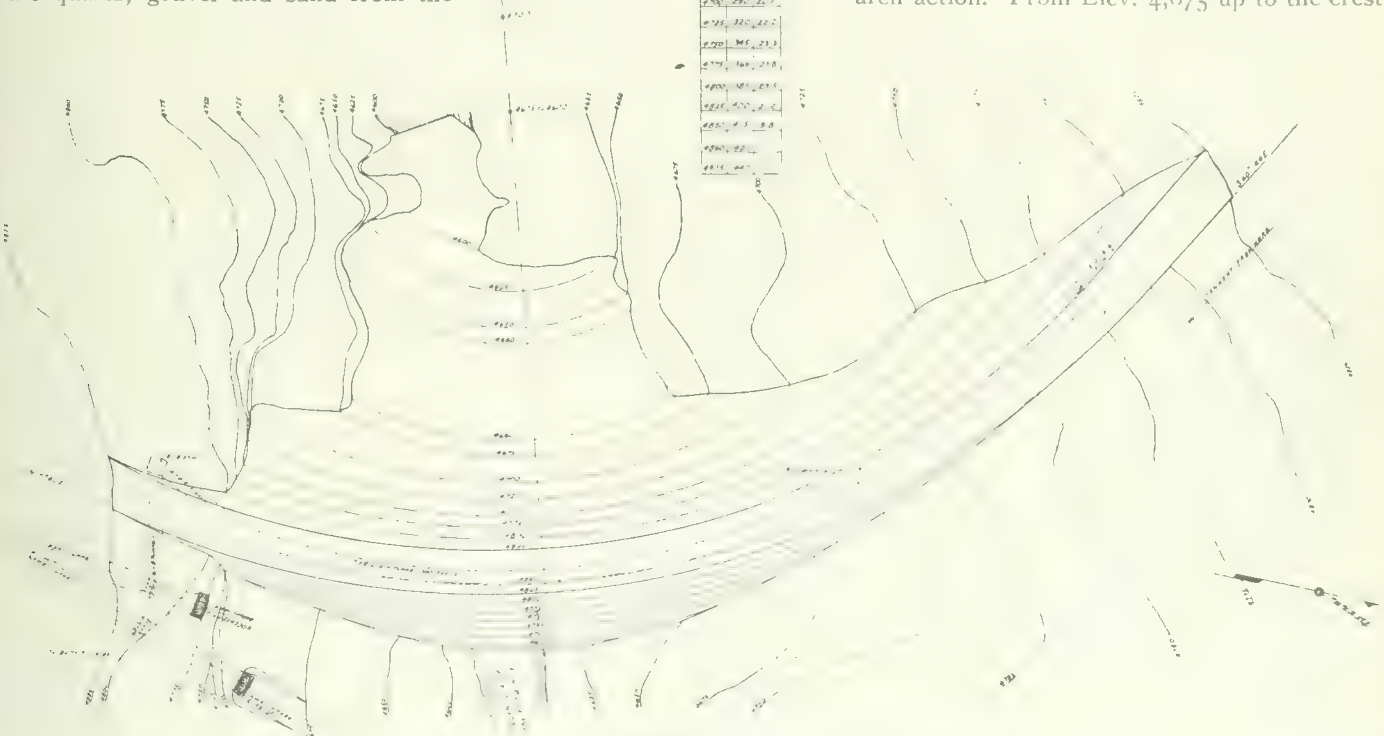

Fig. 2.—Lake Spaulding Dam and Tunnel Intakes.

The Lake Spaulding dam is provided with an inspection tunnel, a drainage system and contraction joints; which are usual features in dams of large proportions. These details are shown plainly in Figs. 1 and 2. The section of the arch above Elev. 4,660 is of such dimensions that it will stand an extension of 35 ft. in height above the present crest elevation (4,825) without any addition to its thickness. The maximum arch stress (q in Formula 1, page 317, *The Canadian Engineer*) will exist at Elev. 4,775 with the water level at Elev. 4,860, or 260 ft. above the river bed, and will amount to 23.8 tons. It is fairly

constant over the greatest portion of the structure, as can be seen from the table in Fig. 2.

In order to cut down the first cost of the structure the section was not given the required thickness for the ultimate height of 305 ft., but only the thickness necessary for a 260-ft. dam. So, when the time comes to extend the crest of the dam to Elev. 4,905, a slab of concrete must be added to the downstream face, and, in order to effect a good bond between the present dam and the new slab, the downstream face of the present dam has been stepped off and a sufficient number of iron rods (old rails) have been left protruding several feet to grip the new slab and hold it in place.

The two outlets have their intakes through solid rock at a point about 50 ft. upstream from the upstream face. These intakes are covered with a heavy grating of flat steel bars set on edge, and are the ends of short steel pipes which extend into tunnels to a gate chamber in each. The intake pipe tapers from 10 ft. to 6 ft. at the gate. The gate has a cast steel butterfly valve which is operated through a lever and gear mechanism by either hand-wheel or 7½-h.p. induction motor specially designed for the purpose. Access to this chamber is provided through a tunnel which connects with the inspection tunnel into the dam, this tunnel being driven through the rock, and by means of a vertical shaft is brought above the dam to the gate house. One intake is to Elev. 4,670 and the other is located 100 ft. above. The upper intake slopes downwards about 48° until it meets the lower tunnel, this slope starting a few feet back of the upper butterfly valve. About 1,000 ft. downstream the single pressure tunnel, which is concrete lined, ends in an adit, and is there provided with a second butterfly valve and also with two pressure reducers. Later, it is intended to install á 5,000-kw. turbine and to let this act as a pressure reducer by utilizing whatever head there may be in the reservoir. From this point the water flows by gravity towards the power house below, of which one is built, and four more projected using the same water.

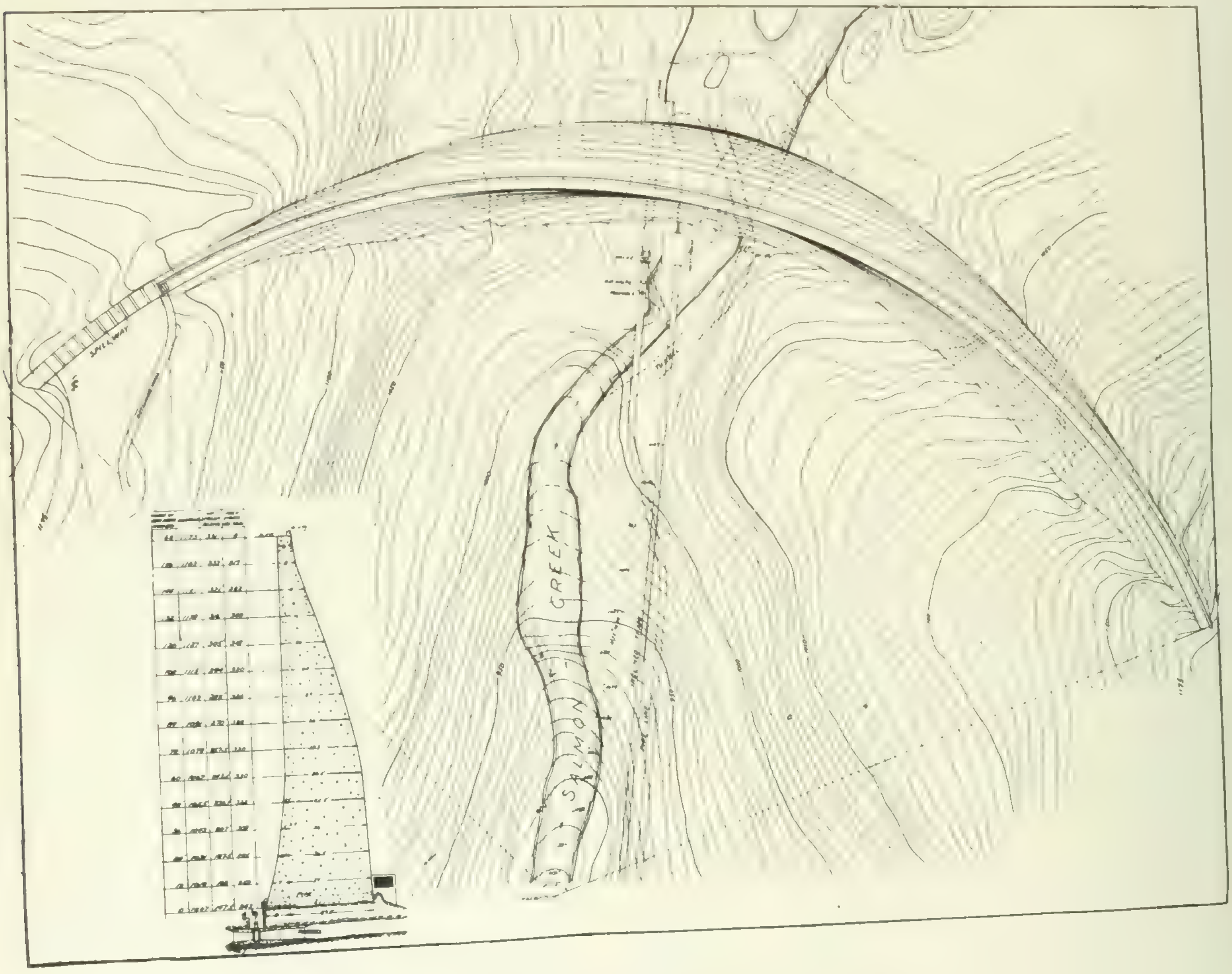

Fig. 3.—Salmon Creek Dam, Near Juneau, Alaska.

In the actual design as used (Fig. 2) the writer's arch theory and the shape of the upstream face suggested in designs submitted by him, have been followed except near the foundation, as already explained.

This dam has developed one vertical crack between each contraction joint, tending to show that, for this case at least, 80 ft. between each of these joints was too great a distance. The cracks and the contraction joints close when the water pressure comes on the structure. The dam, as far as completed, contains 153,000 cu. yds. of concrete. A saving of 46,000 cu. yds. was brought about by the new design. The cost, including everything except

outlet mechanism, was $8.50 per yard. The expected unit cost for the completed dam is $6.30.

Salmon Creek Dam, Near Juneau, Alaska.—This dam is built by the Alaska Gastineau Mining Company for the purpose of storing 18,000 acre-feet of water. The catchment area is only 7.5 square miles, but the precipitation is more than 100 inches per annum, giving a run-off of about 7.3 second-feet per square mile.

Fig. 3 shows the plan and section of this dam, 168 ft. high above the river surface, containing 52,000 cu. yds. of concrete, having 1.25 barrels of cement and 5 per cent. of hydrated lime per cubic yard. The unit cost of this dam, including everything, was very nearly $7.50 per yard.

As can be seen from the contour map, the sides of the canyon form an unusually regular V, and therefore all the different arch centres could be located on one common centreline. The crest width of the dam is approximately 550 ft., measured in a straight line, and the arch at this elevation subtends an angle of 113°. The centres and the lengths of the upstream radius are shown for various arch slices 12 ft. apart in elevation, and the unit axial stresses are given in the table adjacent to the section of the dam (Fig. 3).

To provide better accommodations for the spillway, the curve for the top 12 ft. of the dam was struck from the same centre, therefore the warping of the faces commences 12 ft. below the crest, and continues down to the foundation. The form work for this type of dam is no more difficult than for an ordinary arch dam, as far as the carpenter is concerned; he gets his points about every 10 ft. apart, and it makes no difference to him whether he builds up the face of a cylinder or an inverted cone (approximately). The surveyor, however, has to be more careful than with the layout of an ordinary arch, as, in the present case, there are more calculations to be made and to be followed.

From the table on Fig. 3 it can be seen that the length of the longest upstream radius is 333 ft., and the length of the shortest 147.5 ft., the ratio between the two being $\frac{333}{147.5} = 2.26$. Had the length of the upstream radius been kept constant, the thickness of the dam at the bottom would have had to be increased 2.26 times for approximately the same axial stresses. Relative to this, it should be noted that the arch stresses in the table assume the arch to take the total load, but in reality the stresses are somewhat smaller, as the cantilever takes part of the load. The triangular piece, 10 ft. wide at the bottom, is not considered in the table giving the arch stresses. This is added to the lower part of the dam on the downstream side for the purpose of stiffening the cantilever where it is highest.

To have kept the subtended angle constant at 113° at all elevations would have necessitated a greater ratio than 2.26 between the length of the two upstream radii already referred to. Had this ratio been increased the structure would have been overhanging too much in places, and therefore this increase could not be made. This simply shows that it is not always possible to make theory and practice coincide exactly. To have kept the central angle constant at 113° in this case would have required greater bottom width of the site. The saving of this type of dam compared with an ordinary arch dam for this site was somewhat over 20 per cent. The construction material was gravel from the reservoir bottom in the immediate vicinity of the dam. This gravel was scraped into a hopper by means of a drag bucket. From there a 24-in. belt conveyer elevated the same to a screen, where it was separated into sand and pebbles in order to be remixed later into correct proportions. The oversize pebbles were delivered to a crusher and after crushing, returned to the screen. Two 18-in. belt conveyers carried the sand and pebbles respectively to the mixing house located near the central hoist. After leaving the mixer the concrete was hoisted, say, 50 ft. above the dam level and distributed by gravity through steel chutes to the different parts of the works. Ordinary good progress was 400 cu. yds. per day. This dam is provided with two expansion joints which was deemed sufficient on account of the fairly slender, and therefore more elastic, body.

The structure has been in use for two seasons and only one crack has developed, located near the spillway. Cubes made from the concrete were crushed from time to time and results obtained were about as follows: 1,100 lbs. per sq. in. at 28 days, and 1,800 lbs. per sq. in. at 60 days. This dam was not plastered on the upstream side, and experience has proven that this is not necessary, either.

HUDSON BAY ROAD

The acting minister of railways, Hon. Dr. Reid, recently gave the House at Ottawa some information respecting the Hudson Bay Railway. Up to the end of last year, the expenditure upon this road, which will be an everlasting tribute as to what politics can thrust upon a country, was $15,465,304. The length of the line from Le Pas to Port Nelson will be 424 miles. As acting minister of railways, Dr. Reid apparently felt it necessary to defend the road from its critics. He did it in a way which makes us believe that away back in Dr. Reid's innermost thoughts where political considerations are not allowed to enter, an opinion exists that the road is a farcical enterprise. He said, among other things, "While I myself may have had grave doubts as to the feasibility of this undertaking, yet I have come to the conclusion . . . that this road will be of value to the country in time to come." There was no doubt in his mind as to the navigability of Hudson Bay and Straits "for several months of the year." "But," he added, "it is true that during the first season, two vessels were cast away right at Nelson under circumstances which have never been satisfactorily explained," and "which have absolutely no bearing upon the practicability upon the Nelson route."

Dr. Reid even allowed his enthusiasm to say that he believed for the amount which the road will cost, it will "in years to come have a military value which will be well worth while," information which should be of interest to the minister of militia. "It is not expected, of course," said Dr. Reid, "that there will be any great rush during the first few years after the completion of this road and harbor." Continuing in the same strain, he says: "It is, of course, unfortunate that this great expenditure was commenced only a short time previous to the outbreak of war."

Dr. Reid's eulogy of the Hudson Bay railroad reads as if he, an unwilling victim, had been thoroughly instructed as to what to tell the House. But he said his piece very badly. However, what can we do when The Graingrowers' Guide, for example, says: "The East may as well understand that the West believes in the Hudson Bay route and will brook no interference with the scheme." Experience sometimes has to be bought dearly.

A surveyor in an English municipality is making investigation as to the growing of osiers on sewage works.

THE PROPER USE OF GRAVITY CHUTES.*

THE concrete gravity plant has had a very rapid development because of its undoubted economy in the time and labor cost of distributing concrete and its practically universal adaptability to all classes of concrete structures. The straight lift in a tower for the vertical distance between the mouth of the mixer and the top of the forms, and then an additional lift of about 1 foot for every 3 of horizontal distance between the two before turning the concrete over to gravity to carry it across from the tower to the forms, is about as near to Nature's absolute foot-pound requirement as can well be devised.

Like any new process which, because of easily apparent advantages, comes rapidly into general use, its use has outrun the rules of practice which a more conservative introduction would have established for it, with the result that every user has made his own rules with little guidance except his own experience and with as variable a product as this procedure might suggest. It is well, therefore, that some thought be given to the statement of some of the fundamental conditions which must obtain to insure a good concrete, which is of absolute importance, as well as to realize the largest ultimate factor of economy in operation, these two ends being obtained by the same means, the one depending on the other, the best concrete being the most economical to handle.

The typical plant consists of a tower with a hoist bucket which takes the batch of concrete from the mixer, a receiving hopper with a controllable gate near the top of the tower into which the batch is dumped from the hoist bucket, and a series of chutes or troughs which carry the concrete to the forms. The tower is frequently as high as 200 feet and the line of chutes may carry the concrete as far as 500 feet from the tower; and by using a relay tower the concrete is placed in the forms at 1,000 feet from the mixer. The chutes may be connected in a straight continuous line from the hopper to the forms, or this line may be interrupted by line gates through which the concrete is dropped a vertical distance through a closed pipe and then to the forms; or by an assembly of horizontal swivel-connected chutes it may travel in a more or less zigzag path, dropping from the end of one chute into the swivel head of the chute below as it proceeds.

The matter of first importance to the successful operation of the gravity plant, as well as of any method of distribution, is the condition of the concrete when it is discharged from the mixer. Concrete is in proper condition for the gravity plant when it has been subjected to the action of a well-designed mixer long enough to thoroughly incorporate all of the aggregates, the batch being assembled with the proper amount of water to hold all of the aggregates in suspension, the resultant mixture being a viscous, homogeneous mass. As to how long the batch should stay in the mixer and as to the amount of water in percentages which this requires, our interest, so far as the chutes are concerned, must be confined to resultants and we must consider these questions as proper subjects for separate discussion. The concrete should not be so dry that it will not level off on top as it stands in the bucket, nor should it be wet enough to show water on top of the bucket if left standing for an appreciable length of time, nor to allow a stone to sink much over its thickness when placed on top of the mass.

Too dry concrete limits unnecessarily the range of distribution from a tower of a given height by requiring a steeper chute to carry it. A wet concrete which allows the heavier aggregates to settle to the bottom will separate in travel and is to be avoided as one of the unpardonable sins. By all means let the concrete be too dry rather than too wet; but there is the right consistency which avoids both extremes. But these problems are problems of mixing, however vitally they may affect the economy of the distributing plant. Properly assembled and well mixed concrete will maintain its integrity by whatever method it may be distributed, and concrete which is too wet will allow the stone to settle to the bottom of the form and the mortar will come to the top regardless of the means used to carry it there, while concrete properly assembled, but too hastily mixed, will be very much improved by the movement through a line of chutes as against any other method of transportation. It must be borne in mind, however, that the gravity plant is a plant for distribution and not for mixing and that the concrete must be good concrete, well mixed when it is delivered to the hoist bucket, or it cannot be expected to be good concrete when the forms are removed.

If the concrete reaches the chutes as a homogeneous mass the slope of the chutes is not of vital importance. That slope is generally the best which will allow the concrete to flow with the least velocity which will insure its passage, although a vertical drop in a closed pipe is a feature of many installations on important work. Such vertical lines, however, should have baffles every few feet to arrest the drop and the concrete should be distributed at the bottom by means of a horizontal chute whenever possible and not directly from the vertical line into the forms. The required minimum slope to carry the concrete properly will vary with the character of the aggregates, the average slope for small, round gravel being 1 of rise to 3 of run, or an angle of about 18 degrees with the horizontal; the slope for 1-inch stone, about 1 to 2¾, or 20 degrees; for 1½-inch stone, 1 to 2½, or 22 degrees; and for 2-inch stone, 1 to 2¼, or 24 degrees with the horizontal. It is better practice on a long line to hang the chutes with a gradually and very slightly increasing grade as they travel toward the lower end, such a grading being less likely to cause an overflow in the chutes than the reverse. The final distributing section which places the concrete in the form should retard the concrete to as slow a movement as will carry it at all.

In the travel through the chutes the concrete should flow in a constant, uniform stream so far as possible. The man on the tower at the hopper gate is a very important member of the operating crew. An intermittent rush of concrete is apt to congest the chutes, causing overflows, shut-downs, the retaining of concrete in the tower hopper for an undesirable length of time, and damaged work.

The concrete should be placed by the chute as closely as possible at the point where it is to remain. For floors and shallow beams the final chute section should be easily portable with the mouth close to the forms and the concrete travelling as slowly as it can be made to run. For column forms and deep girders the gravity plant provides a closed, flexible drop pipe with frequent baffles or arresters for placing the concrete in the bottom of the form, obviating the objectionable practice of dropping it in the open from the top. If concrete is dropped from the top of a column form in the open, or even in a closed pipe without obstruction, the kinetic energy of the stones in the aggregate will drive them toward the bottom of the mass, separating them from the mortar; while if frequent baffles are places in the vertical pipe the mass will retain its homogeneous character.

*A paper presented before the American Concrete Institute by W. H. Insley and C. C. Brown of Indianapolis.

REFUSE REMOVAL AND DISPOSAL IN MOOSE JAW

A DESCRIPTION OF PRACTICE SUITABLE FOR CITIES OF TEN THOUSAND TO FORTY THOUSAND POPULATION, GIVING TABLES OF COSTS.

By Geo. D. MACKIE, City Engineer.

A CAREFUL record was kept during last year of the quantity of refuse removed and disposed of, and the cost of removal and disposal, and these figures are presented here, not with the idea that the results achieved are specially good, but rather that they may form a basis of comparison by engineers of other cities and towns.

Unfortunately the keeping of records and the collection of data in connection with this phase of municipal work has not been extensively practiced by engineers, more especially in Western cities, and this is no doubt due to the fact that during the last few years the major portion of a city engineer's time has been spent in the designing and carrying out of new works, rather than in supervising and managing the many utilities which usually fall within the sphere of a city engineer's activities.

It is unfortunate, but none the less true, that many cities spend large sums of money on civic enterprises, and after these works have been completed, councils grudge the necessary money to assure that these same works shall be run economically, and in the best interests of the city. The council of the city of Moose Jaw, however, have not been slow to recognize the fact that the money spent on the management of the various works under their control is money well invested.

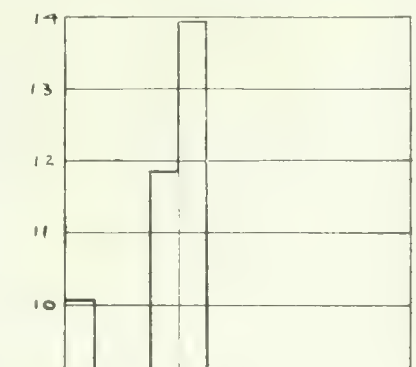

Diagram 1.—Monthly Variation in Percentage of Garbage and Refuse Removed.

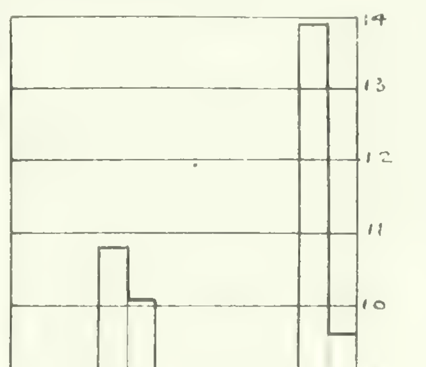

Diagram 2.—Monthly Variation in Percentage of Total Refuse Removed.

Prior to March, 1915, the management of the scavenging department was under the control of the health department, but at that time was transferred to the city engineer's department, and by this transference many economies have been effected, more especially in the number of teams employed. The whole work is carried out with the city's own teams, and prior to the work being taken over by the city engineer, it occurred time and again that the health department might be short of teams to carry out their work, while the engineer's department might have a surplus of teams, and no work to put them to.

In the removal of household refuse an organization is required that is sufficiently elastic to take care of the wide variations in the quantity of refuse that has to be dealt with from month to month, and where a scavenging department has no other work to engage in, the consequence is that at certain seasons there is an insufficiency of teams to cope with the work, and at other times it is necessary to hire teams to overtake the work. When, however, this department is combined with, say, the street maintenance department, and in this connection it must be understood that the writer has especially in mind the work required to be done in cities of, say, from 10,000 to 40,000 population, the combined departments will possess the necessary equipment to take care of all the work without having on hand any idle teams, or having such a rush of work that it is necessary to hire teams. This statement is borne out by Table 1, which shows an increase of garbage and ashes removal in November as compared with October, of over 156 per cent., which was overtaken by the engineer's department without the necessity of hiring a single team.

As already stated, the operation of the refuse removal and disposal departments is under the control of the city engineer, and is operated by the works department branch. The city possesses its own stud of horses, and the necessary wagons and other plant for the operation of the department. All horses, wagons, etc., owned by the city are controlled by the works department, and are hired out by that department to the various departments requiring teams, at a rate of $5 per day of ten hours. Any surplus, after paying the cost of running the stables, repairs to rolling stock, etc., is divided amongst the different depart-

ment in proportion to the amount spent by them in team hire.

Moose Jaw has a built-up area of 4.87 square miles, and an estimated population of 20,000. All household refuse is removed weekly, and is separated into two classes for removal, *viz.*, (1) garbage, which includes animal and vegetable wastes, and household rubbish, and (2) ashes. The garbage is disposed of by burning in the city refuse destructor, which is situated about 1.33 miles from the centre of the city. The ashes are used for filling up low-lying places in the city. Householders must supply a covered galvanized can of about 2 cubic feet capacity for garbage, which must be placed at the rear end of the lot for convenience of handling by the teamsters. The wagons used in garbage collection are of wood with canvas cover, and of 3½ cubic yards capacity. No effort has been made to insist on ashes being deposited in cans; householders simply deposit these at the rear of their lots, so that they may be readily collected and removed. Last year the average number of teams employed removing refuse was 5.9; the largest number used was 9.8 in May, and the minimum 4.1 in August.

Table 1.—Refuse Removal, 1915.

Month.	Garbage (tons)	Ashes (tons)	Total (tons)
January	354.17	169.50	523.67
February	296.77	196.50	493.27
March	284.15	157.50	441.65
April	406.85	246.00	652.85
May	479.59	134.25	613.84
June	297.94	201.00	498.94
July	211.08	135.50	344.58
August	237.57	117.00	354.57
September	239.59	136.50	376.09
October	238.73	88.50	327.23
November	231.02	607.50	838.52
December	152.45	430.50	582.95
Totals	3,429.91	2,618.25	6,048.16

Diagram 1 shows the monthly variation in percentages of garbage removed annually, and Diagram 2 the monthly removal in percentages of the total refuse removed.

Table 2 gives the quantity of refuse removed and detailed statement of the expenditure for removal, as well as the cost per ton.

Table 2.

Quantity of refuse removed—		
Garbage	3,429.91 tons	
Ashes	2,618.25 tons	
Total	6,048.16 tons	

Cost of removal—	Total cost.	Cost per ton.
Teaming	$7,217.75	$1.202
Supplies	98.93	0.006
Superintendence	688.65	0.112
Engineer's office expense	145.10	0.024
Insurance	100.44	0.016
Totals	$8,250.87	$1.36
Less credits	618.25	0.10
Net cost	$7,632.62	$1.26

The percentage of garbage removed to ashes was:—

Garbage and rubbish	56.71 per cent.
Ashes	43.29 per cent.
	100.00 per cent.

The cost of removing each class of material was:—

	Cost.	Cost per capita.
Garbage and rubbish	$6,017.63	$0.30
Ashes	1,614.99	0.08
	$7,632.62	$0.38

The quantity of each class of refuse removed per capita was:—

	Per capita per annum.	Per capita per day.
Garbage and rubbish	342.98 lbs.	0.94 lbs.
Ashes	261.82 lbs.	0.72 lbs.
Total	604.80 lbs.	1.66 lbs.

Based on the above figures, and assuming six persons per family, which is a fair average for Moose Jaw, the quantity of refuse removed per family per annum was 1.81 tons at a cost of $2.28.

The refuse destructor is of the Heenan and Froude type, and was erected in 1912. It has a capacity of 50 tons per day of 24 hours, and in 1913 it was run at full capacity, but owing to the decrease in population which occurred in Moose Jaw, in common with all Western cities, it was only operated 56 per cent. of the total possible hours of working, and as a consequence, the cost per ton of incineration was much higher than in 1913.

The total quantity of refuse destroyed was 6,027 tons, and Table 3 shows the expenditure in detail, together with the cost per ton.

Table 3.

	Total cost.	Cost per ton.
Wages	$ 7,595.88	$1.261
Repairs and supplies	701.53	0.116
Hauling clinker	519.20	0.086
Light and water	338.80	0.056
Insurance	137.27	0.023
Engineer's office expenses	51.74	0.008
Total operating cost	$ 9,344.42	$1.55
Depreciation	553.04	0.091
Interest on invested capital	2,378.86	0.394
Gross total	$12,276.32	$2.035
Less steam sold	454.46	0.073
Net cost for 1915	$11,821.86	$1.96

Summing up, these results show the following costs of refuse removal and disposal for 1915:—

Table 4.

	Removed or destroyed (tons).	Cost.	Cost per capita per annum.	Cost per family per year.
Refuse removed	648.16	$ 7,632.62	$0.3816	$0.044
" destroyed	6,027	11,821.86	0.591	0.068
		$19,454.48	$0.0726	$0.112

All refuse is weighed at the destructor. The weight of ashes is computed.

A charge of $2 per load is made for the removal of trade refuse. The city does not remove all manure.

Closely connected with this subject is the question of night soil removal. All houses in Moose Jaw not having

sewer and water services, are required to provide suitable outside closet accommodation, and the city provides suitable pails of 1½ cubic feet capacity each, at a total cost to the householder of $3.05. The contents of these pails are removed weekly. In summer the removal is carried out at night, and in winter during the day. The contents of the pails are discharged into the detritus chamber at the sewage disposal works, situated 1½ miles from the centre of the city. After removal of contents, the pails are steamed with steam from the incinerator, and disinfected. Two men are employed at the pail-washing shed, and in summer four teams are used for carrying out the work of removal. The contents of the pails are emptied into an approved swill tank, the dirty pail is taken to the pail-washing house to be cleaned, and a fresh pail left in its place. In winter the pails, with contents, are removed to the disposal works.

Table 5 gives details of last year's operations.

Table 5.

Number of pails removed, cleaned and contents disposed of	102,497
Average number per week	1,971
Total cost of work	$10,429.49
Total cost per pail removed, cleaned, returned and necessary repairs, etc.	$0.10

TREATED WOOD BLOCK FOR FACTORY FLOORING AND MISCELLANEOUS USES.

Since 1900 there has been a steady and rapid increase in the use of creosoted wood blocks for paving the streets of our cities. A more recent development, and one which promises to become an important source of business to the manufacturers of these blocks, has been their adoption for a variety of uses other than street paving, according to C. H. Teesdale in the current issue of "Wood Preserving." Those qualities which make the wood block desirable for street work, it seems, should also make it desirable for flooring where heavy trucking, the moving of heavy machinery, etc., make the maintenance of floors a serious problem.

Plants producing the largest quantity of this material, point out that the wood block flooring problem naturally divides itself into two classes: (*a*) Blocks used in very dry situations, as in factories and warehouses; (*b*) those used in alternately wet and dry, or in wet situations, as in stable floors, docks, wharves, slaughter houses, etc., where the blocks are exposed to the weather, to flushing with water, etc.

The treatment and method of handling the blocks differs radically in the two cases. The concensus of opinion is to use a distillate creosote, especially for dry situations, and a heavier paving oil for wet conditions.

Comparatively light absorptions (from 5 to 8 or 10 lbs. per cubic foot) would prove satisfactory for dry situations. Heavier absorptions ranging from 8 to 16 lbs. per cubic foot, are recommended for alternately wet and dry or for wet situations.

Southern yellow pine 3-in. blocks air-dried, are preferred.

In a large proportion of cases it was reported that wood block was easy on the feet of the workmen and that they like to work on it. Noiselessness, ease of repairs, low upkeep cost, good trucking surface, saving of breakage in tools and fragile metal parts dropped on the floor, warmth, and cleanliness and durability were all reported as advantages of wood block flooring.

THE DESIGN OF PASSENGER TERMINALS.*

By J. L. Busfield, A.M.Can.Soc.C.E.

It is only necessary to compare the modern railway passenger terminal with some of the older types, to be struck with the great advances made, to the benefit of both the public and the railway companies. Not only have conveniences and arrangements been provided which were undreamt of a few years ago, but the great element "Safety first" has entered very largely into the operation of the trains.

Dealing with the subject from the point of view of the engineer, one's first impression is that a study of existing terminals is of little real value in the preparation of a design for a new terminal owing to the apparent lack of similarity in all of the important features of the terminals. A closer and more intimate study, however, reveals the important fact, that notwithstanding large differences in shape, size, traffic and local conditions, there is to be found a remarkable similarity in the general principles upon which the designs are being carried out in the terminals of to-day. It is proposed to deal mainly with these general principles in this paper, and although the financial side of the problem has been purposely omitted, great importance and ultimate bearing on any design must not be overlooked.

Architecture.—The subject of architecture as applied to passenger terminals is one on which, no doubt, volumes could be written, but there are one or two points to which it may not be inopportune to refer. One of these is the external design and appearance of the station building which should naturally express the generally accepted idea of a railway station, and also, especially in the case of a large city, have the character of a monumental gateway and entrance to a great city and great railroad.

Another important point is the necessity of cooperation between engineers, architects and operating officials. The architect is possibly a little inclined to err on the side of "a thing of beauty is a joy forever," while the engineer, on the other hand, is rather apt to be purely utilitarian in his ideas, and the operating officials are naturally most concerned in being able to handle the traffic in and out of the terminal in the most efficient manner. In order to obtain the best all-round results a thorough cooperation of the different departments is essential, and instead of turning over the preliminary plans to the architects, as is frequently done, a thorough study of operating methods, traffic and engineering problems should first be made, preferably by a committee representing the various departments interested.

Still another feature which both architects and engineers should try to remedy, is the long distance the passenger has to walk between the entrance to the station and his train. Any effort to reduce this distance to a minimum will be well repaid. In one of the most modern terminals in the States, the average passenger walks a distance approximately 1,000 ft., and although there is prevalent an idea that the public can be fooled into believing that once they enter the station portal they are close to their trains, after a few trains have been missed, however, it is realized that the station is not quite as convenient as might have at first been imagined.

While discussing architecture, mention must be made of the rather remarkable differences in sizes of waiting rooms and other facilities, even in terminals which cater

*Abstract [illegible] Civil Engineers, March 9, 1916.

to the same volume and nature of traffic. A study of the actual figures reveals the fact that the sizes of waiting rooms vary from 0.1 to 5.0 sq. ft. per passenger using the station. Apparently, therefore, there is a large amount of guess work entering into the design of station buildings.

Electric Operation.—The electrification of railways in terminal zones has done more than any other single circumstance to alter and improve the conditions existing in large passenger stations. The abolition of smoke and steam, together with their resulting dirt, not only improves the whole atmosphere, but also leads to brighter, cleaner and generally better conditions of all the various parts of the station. Apart from the improved atmospheric conditions, electric operation has made possible a type of terminal in which the tracks are entirely underground, or at any rate, covered over by the station building or offices. The importance of this possibility is that large areas of valuable city real estate need not be entirely

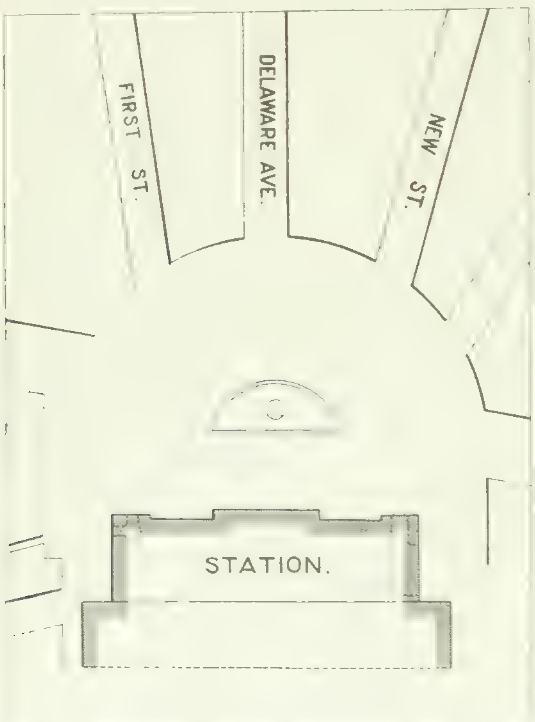

Fig. 1.—Plan of Approaches to Washington Union Station.

devoted to trackage, but can also be used for revenue-producing purposes, such as offices, hotels, etc. A terminal such as the Grand Central in New York would have been an impossibility without the use of electric power.

In addition to this feature there are others of equal importance developed by the use of the electric locomotive. For example, the greater acceleration of this type of engine compared with the steam engine results in the general speeding up of the train and switching movements in the yards, which is a great benefit at any large traffic centre. It is also often possible to utilize steeper grades when electric locomotives are used, this feature again being illustrated in the Grand Central, New York, where there are grades of 3% leading to the suburban level. The operation of a terminal with electric power is also frequently simplified by the fact that only one type of locomotive is used for all the various movements, whether they are empty drafts, long distance trains, or only switching services.

Trainsheds.—There has been a marked change in the standard form of trainshed, the old type of large single-span roof being more or less obsolete as far as the modern terminal is concerned. This type had a number of disadvantages which are mostly overcome by the improved form of umbrella shed now used. That this idea is not new, however, is shown by the following item taken from a copy of "Engineering News" nearly twenty years ago:—

"An arrangement to facilitate the ventilation of and the carrying off of smoke and steam from the interior of train sheds is proposed by Geo. C. Croker, of Boston. It is more particularly applicable to low roofs of moderate span, and consists of a continuous ventilator or chimney over the middle of each track, and running the whole length of the track. Whatever may be the desired height of the ceiling or roof this ventilator extends down nearly to the top of the smokestack."

The use of this type of shed at the Windsor Street Station, Montreal, the Central Station, Ottawa, and at many other important stations, has made it so familiar that no further description is necessary. Apart from the abolition of the smoke nuisance they have the advantage over the large span roof in that they are less costly to erect, less costly to maintain, and also safer. The condition of the air which accumulates in the top of the dome-like structure of the single-span roof has been proved to shorten the life of the steel very considerably.

Site.—In selecting the site, good judgment has to be used in order that undue restrictions will not occur, such as might be caused by streets, valuable properties and natural conditions. It has often happened that restrictions of this nature have occurred to such an extent as to be actually obstructive to the construction of an efficient layout of the tracks and buildings.

Neighboring Conditions.—It is not only the natural controlling features within the station site that affect the layout of any terminal, but it is also necessary to make a complete study of the immediate neighborhood, both with regard to the railway, and also with regard to the adjoining part of the city. One feature playing a prominent part in any design is the elevation of the tracks, in relation to the natural ground level, as terminals with the approach tracks either above or below the latter will usually be of a very different type to those where the tracks are at grade. Terminals with two or more stories are far more common than they used to be owing to the fact that it is often difficult to approach a terminal on the ground level without having a number of grade crossings, which to-day will not be countenanced. In some cities, however, the natural features favor the adoption of a layout with the tracks level with the adjoining streets, without any grade crossings, but the two-story terminal has a number of advantages, such as economy of ground space, facility of handling baggage at a separate level from the platforms, and the segregation of traffic. The relative location of the station, the coach yards and engine sheds have an important bearing on the final layout of the terminal on account of the switching movements necessary for the moving of the empty trains. When the coach yards are located at some distance from the terminal the road engine usually makes an independent run, while the empties are handled by yard engines, making it desirable that a means should be provided for running the engine around the train, otherwise it will be tied up for a lengthy period in the platform. As an alternative the train may be pushed into the trainshed backwards, but this method is not considered to be good practice if the distance is at all great. A large number of the movements involved in these forms of operation are eliminated in the case where the coach yard is adjacent to the terminal, and the road engine can hitch on to its train and back it into the trainshed.

It should hardly be necessary to mention the desirability of having the station face an important thoroughfare or public square, but in cases where there is competition between different railways the prominence of a terminal building is apt to be of vital importance. A little study of this aspect and perhaps a little expenditure on real estate will usually be repaid by the improvements effected. This is a feature which is given considerable prominence in Europe, as almost every city of any importance has a dignified and spacious approach to its railway station, frequently made into the form of a public garden. It is not to be expected that railway companies will go to the entire expense involved in every case, but it is to the interest of the municipality to see that the approaches to its "gateway" are worthy of the city, because, after all is said, the visitor's first and last impressions are those which, unconsciously, perhaps, will be retained. A terminal which may be considered a model for a fine location with regard to the immediate vicinity and approaches is the Washington Union Station, illustrated in Fig. 1. This result, however, was largely obtained by the cooperation of the District of Columbia and the railway companies interested in the terminal.

Nature and Volume of Traffic.—The size of any proposed terminal is naturally dependent on the volume of anticipated traffic. This volume has to be carefully analyzed, because it is not the volume alone, but the relative percentages of suburban and main-line passengers, and also the quantity of mail, baggage and express matter that determine the necessary size and requirements. Taking the effect of the predominating kind of passenger traffic on the station building it will be found that the commuter requires different and less facilities than the long-distance passenger. The requirements of the former are few, his usual idea being to rush through the station to or from his train in the shortest time possible, although he may occasionally stop at the bookstall, ticket office, etc., but not frequently. The latter, on the other hand, puts in quite a considerable amount of time in the station, visiting parcel, baggage, waiting and lunch rooms in addition to the ticket office, so that all these facilities have to be provided to a greater or less extent depending on the proportion of this part of the traffic. At stations where many connections are to be made, it is necessary to provide for a large number of people in the waiting rooms.

The nature of the traffic not only affects the station building, but it also has a direct bearing on the size of the track-layout. The handling of a definite number of passengers requires less trains if they are commuters than if they are long-distance travellers, and at the same time suburban trains can be dealt with at a quicker rate than long-distance trains, because they can be unloaded quicker and do not need to be placed at their platforms so long before their schedule time for departure. This fact, however, is somewhat offset by the heavy "peak" loads that occur in conjunction with the former class of traffic at the morning and evening rush hours. In Fig. 2 is shown a typical hourly distribution of suburban traffic throughout the day. Main line traffic has its variations principally with the seasons of the year, and at the same time there are a number of stations where extraordinary heavy loads have to be handled for short periods, an example of which is the inaugural crowds at Washington.

Through the courtesy of officials connected with each of the terminals mentioned therein, the writer is able to present in Appendix 1, a variety of statistics covering the operation of a large number of important terminals on this continent. Bearing out the above statements with regard to the relationship between suburban and express traffic, the following averages are taken from this appendix:—

	Long-distance.	Suburban.
Passengers handled per day, per track	[illegible]141	[illegible]
Number of trains per track	15.4	29.4
Passengers per train	84	160
Time train is at platform before departure	27	11
" " " " " after arrival	16	[illegible]

Segregation of Traffic.—On account of the differences, already mentioned, in the requirements of the commuter and the express passenger, it is advisable, when they both reach large proportions, to separate the one from the other as much as possible. The most notable example where the segregation of traffic has been carried out with completeness and success is the Grand Central Terminal of the New York Central in New York. Local conditions lent themselves to the consummation of this project because the property restrictions necessitated building the tracks on two separate levels, with the result that one level was retained for suburban and the other for express traffic. This idea was carried out not only with regard to the

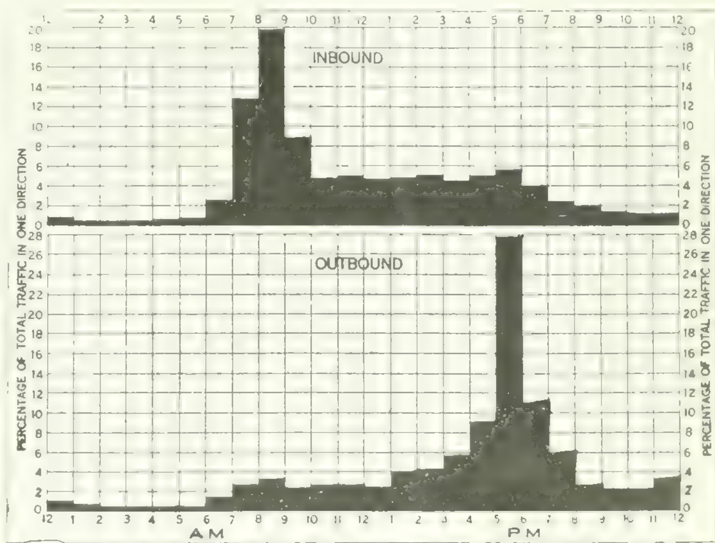

Fig. 2.—Typical Hourly Distribution of Suburban Traffic.

tracks, but also with the building itself, two entirely separate concourses being provided on the different levels together with their independent ticket offices, waiting rooms, entrances and exits. As both the New York Central and the New York, New Haven lines carry a large number of both classes of passengers, the result is that the 76,000 passengers using the terminal every day are able to do so with the minimum of inconvenience and delay. In addition to this separation of the two classes of traffic there is also a partial separation of the inbound and outbound traffic using the express level. A separate "inbound" waiting room together with corresponding exits and carriage ways is provided on a site immediately to the west of the main building and in the basement of the Biltmore Hotel.

At the Pennsylvania terminal in the same city a rather different situation is encountered. This terminal serves both the Pennsylvania and Long Island Railroads, the former carrying express passengers almost entirely, while the traffic on the latter is of a purely local nature. The main idea carried out in this terminal was therefore the segregation of inbound and outbound passengers, but in addition to this, separate entrances and exits were provided for the Long Island commuters. The large difference

in the elevations of the tracks and the neighboring streets gave plenty of available headroom for the construction of two concourses on separate levels, the lower of these being kept for inbound passengers entirely.

Platforms.—Before any plans can be commenced with any degree of detail, standards must be adopted for the size and general features of the station platforms because it will be their necessary number and dimensions that will partly determine the size of the terminal as a whole. The platform sizes, in turn, will depend not only on the traffic, but on the methods of handling baggage, and on the means of approach to the platforms.

Baggage Handling.—There is no question but that the most satisfactory way of dealing with this problem is that of trucking either above or below the track level, and raising or lowering the trucks, as the case may be, to the platforms at a point approximately opposite the baggage cars. In terminals where this system is in vogue baggage may usually be said to be conspicuous by its absence.

Stairways and Elevators.—In terminals where the concourse and baggage rooms are above or below the platform level, stairs and elevators, or as an alternative, ramps, must be provided, and before any conclusions can be formed as to the platform widths, a general idea must be had of the nature and extent of such obstructions to the clear width of the platforms. In the case of commuter traffic a stairway 20 feet wide is not uncommon, but is confined to those situations where large crowds have to be handled in a very short space of time, more particularly in subway stations than in railroad terminals. Taking the more general situation where not more than one or two hundred people per train are provided for, if the traffic on any one stairway can be confined to one direction only, a width of 6 ft. is sufficient. It is often necessary, however, to provide stairways for traffic in both directions, in which case a width of at least 8 ft. is advisable. Of course the width is to a large extent controlled by the rapidity with which it is necessary to clear a platform.

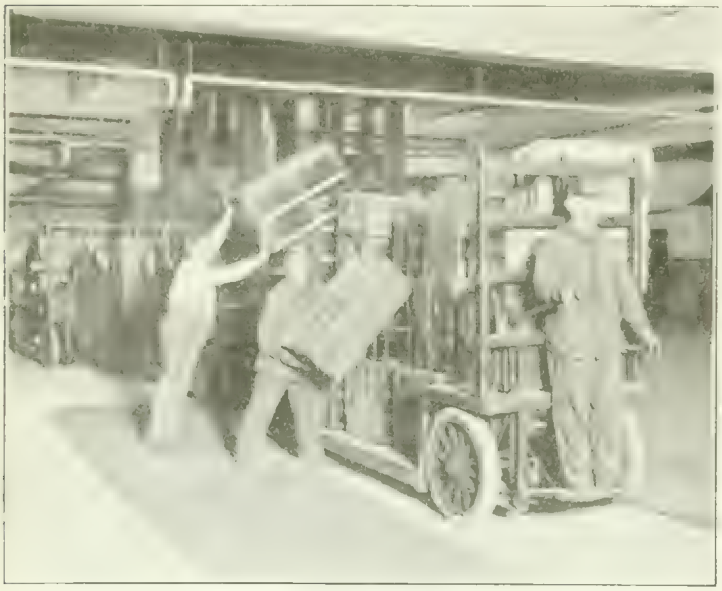

Fig. 3.—Electric Baggage Truck, for Use on High Platforms. (Note Rubber Mat of Old Hose Pipe to Protect Baggage and Flooring.)

The recognized practice in modern terminal construction is to eliminate stairways as much as possible by the substitution of ramps, the slopes of which have to suit local conditions, but which should not exceed 12 per cent., and when space permits 8 to 10 per cent. makes a slope well favored by the public. Elevators are used for the transference of both passengers and baggage from platforms to concourse, and vice versâ, but for the former purpose they are generally used in a purely subsidiary manner, and rarely exceed 5 or 6 ft. in width. Baggage elevators, on the other hand, have to be sufficiently large to readily accommodate the largest baggage trucks, sometimes even two at a time, with the result that it is not unusual to find an overall width of 8 or 9 ft.

Width of Platform.—When a platform is practically free from structures and baggage trucking is eliminated a width of about 16 ft. is found from experience to give satisfactory results, and in other cases, such as where the platforms are only occasionally used for local trains, perhaps, this width can again be reduced. Widths as great as 30 ft. are sometimes necessary when a heavy and continuous inbound commuter traffic has to be dealt with expeditiously.

Height of Platforms.—Although platforms level with the car floors have always been the standard practice in Great Britain, it is only in recent years that they have been in use at all on this continent, except on subways or elevated roads. The Pennsylvania Railroad must be given the credit for first adopting the high platform in a railway terminal in America, and their operation proved so successful that the example set by this road was immediately followed by the New York Central Lines, and to-day they are in extensive use on many of the lines in the East.

The advantages of the high platforms may be briefly stated as follows: (*a*) Facility and rapidity with which trains may be loaded or unloaded; (*b*) the prevention of the public crossing the tracks; (*c*) in stations below street level, a saving of about 3 ft. in the vertical height to be travelled by the passengers; (*d*) in some cases they form a convenient place for the housing of ducts, cables, elevator machinery, signal equipment, etc.

On the other hand, they have certain disadvantages when used in conjunction with our present system of terminal operation, in addition to that of the additional cost. The most important factor against their use is that of the passenger coaches which must be remodelled to serve both high and low platforms. A second objection to their use is the difficulty of trucking across the tracks, and a third is the fact that a special form of baggage truck must be provided, having its floor as low as possible. These disadvantages are not so serious that they can not be readily overcome, and the type of baggage truck used by the Pennsylvania Railroad is shown in Fig. 3. A rubber mat is provided to protect baggage and floor. A rather more serious disadvantage which sometimes arises in connection with the use of the high platform is that if a switch has to be placed in a track within the limits of the platform, it becomes necessary to put a curve in the line of the platform edge in order to provide sufficient clearance for the swing of the ends of coaches using the switch. This is not only unsightly but also dangerous, because if a car door happens to stop opposite the curve, an unobservant person might readily step into the space left between the car and the edge of the platform. Similarly, the outer ends of all platforms are usually curved for a certain length to conform to the layout of the tracks and on the outside of the curves the car doors swing out to an excessive distance from the platform. This is an objection which is difficult to eliminate unless the station site is of such ample dimensions that the platforms can all be confined to the straight part of the tracks.

DISCUSSION ON PAPER.

Hugh Valance, architect of the Grand Trunk, was asked by the chairman to open the discussion. Mr. Valance expressed his appreciation of the paper, especially that part dealing with design of buildings. He stated that in the early days the passenger station looked just like a station and nothing else—all stations were more or less alike. In those days an endeavor was made to work on models from France. The great difficulty is to get a proper expression on the umbrella form of train shed. He said that in architecture it was not so much a case of exact science but of your own choice in problems of design. What would be perfectly correct for him might not suit some other architect. If a man asked an architect to build a house, he could build it; but unless the architect was told his various tastes and requirements the house would be the expression of the architect's taste and not the owner's ideas at all. This holds true right through architectural work as compared to that of the engineer. Mr. Valance told of many engineering structures which with a little architectural treatment would have been very impressive. He spoke particularly about elevators, which are usually blots on the landscape. He explained that he intended no criticism for the engineer, as elevators were engineering problems and were handled from that point of view without regard to appearance.

Regarding terminals he said the question of the length of concourse was an important one. In the South Terminal at Boston, one has to pass 28 tracks sometimes before reaching his train. He thought the remarks in connection with two levels were quite to the point.

H. R. Safford, chief engineer of the Grand Trunk Railway, favorably criticized the paper. He said that for a great many years the public had not been regarded as having anything to do with the design of passenger terminals, but the question had been one for the railroads themselves. It took a long time for the railroads to understand that the public did express their views in this respect. However, he said that he could not see why the public should have anything to say beyond questions regarding their personal comfort while in the station. A passenger station is a non-productive and almost unprofitable investment in a broad sense, although sometimes, owing to competition, a structure of architectural beauty is necessary. Mr. Safford quoted some interesting figures in connection with the increase in traffic and use of terminals. He said that in the Illinois Central station in Chicago traffic had increased 200% in 20 years; Grand Central station, New York, 70% in 10 years, and the Union Station at Toronto, 110% in 25 years. The question the financiers of the railroads have to face is for how long a period of time will the structure they are about to build suit the traffic.

Mr. Safford stated that many advantages were to be had by building high platforms, chief of which is the reduction of liability to personal injury. The only disadvantage is that it is difficult to couple trains, but this will very probably be overcome.

Charles Parker, chief signal engineer of the Grand Trunk, then entered the discussion with some remarks on signal systems.

William McNab, in some remarks as to the architectural features of the paper, said that better stations would be possible if the public would share in the expense of building them. The stations should be feature points of a city. What is wanted in large terminal stations today may be summed up in two features: first of all, the operative features, and next, comfort to passengers. The Pennsylvania station is New York was a sample of extravagant concourse area. It took five or six minutes' walk from the Avenue to the train. He stated that baggage arrangements were better than they had been, but were still capable of improvement.

S. B. Brown suggested that it would be a good thing if a paper on freight terminals and a general paper on the terminal situation were read. It would be of great interest to the members.

A vote of thanks was tendered Mr. Busfield for his most interesting paper.

LIABILITY OF MILITARY RAILROADS

It has recently been decided in France that railroads, though operated under military authority, may be held liable before civil courts for loss and damage claims and for injuries to passengers. So states Walter S. Hiatt, the special European correspondent of Railway Age Gazette.

This decision was given in a test case brought against the Paris, Lyons & Mediterranean. One of its auto-trucks struck a street car and slightly injured a woman passenger. She sued the railroad, which denied its liability on the ground that the act was one of an employee who was mobilized as a soldier, and further, because the railroad itself was being operated under military authority. Various chambers of commerce, whose members had been unable to obtain satisfaction regarding complaints concerning non-delivery of freight, were also interested in any decision as to the railway's responsibility.

The minister of public works, who supervises the conduct of the railroads in times of peace, had issued various rulings regarding the precedence of military freights over civil freights, which at the same time sought to secure prompt handling for the latter, but he had not been able to establish the question of responsibility where shippers had a grievance.

Finally, the minister of war has settled the whole question by stating that the various rulings giving precedence to military transports would in no wise alter the common law rights of shippers or injured persons to sue the railroads through the usual channels of the civil courts in contradistinction to the military courts established in various parts of France for the purpose of hearing cases affecting the public safety.

On the other hand, the ruling has also been made that railroads are not obliged to permit soldiers detailed to munitions factories and other such work to travel at the one-quarter fares established for soldiers both in times of war and peace. Many thousands of soldiers, competent as mechanics, have been withdrawn from active military duty to work in the various government or private factories turning out munitions of war. The railroads charged these men full fares and were fairly deluged by complaints. In every railroad station, and at many street car stations in France, a complaint book is maintained by law for the benefit of the public, response to any complaint being required within one month. These soldiers detailed to civil duties seem to have made complaints through this means almost to a man. The dispute was settled in favor of the railroads on the ground that the men were being paid, in addition to the pay of five cents a day as soldiers, the full wages of the shops in which they were employed.

An underfeed stoker is able to smokelessly burn even high-volatile coals, because when the volatile is distilled, it must pass through the hottest part of the fuel bed before getting out into the furnace. Besides a sufficiently high temperature, the only other chief requirement for the proper burning of the volatile is time, just as it takes time for a cake of ice to melt at summer heat.

THE MOMENT DIAGRAM AND ITS RELATION TO THE REINFORCEMENT IN A CONCRETE BEAM.*

By S. C. Hollister.

IN the past the design of reinforced concrete beams has involved some intricate problems relative to the proper placing of the steel reinforcement in the body of the beam. Extensive analytical methods have been resorted to, or a series of graphic constructions have been necessary, to determine the relative position of the component parts of the reinforcing material.

In the present paper it is proposed to set forth a method of placing the reinforcement for both bending and shearing resistance entirely from the moment diagram. To explain the method it is deemed necessary to review the principles upon which later operations are based, after which its application will be made to a specific design.

Consider a simple beam, uniformly loaded, as in Fig. 1. Let two transverse vertical sections, (1) and (2), be passed through the beam, at distances x_1 and x_2 from the left support. Then from mechanics it may be shown that

$$M_2 - M_1 = \frac{V_1 + V_2}{2}(x_2 - x_1)$$

Whence

$$V = \frac{M_2 - M_1}{s} \qquad (1)$$

in which V equals the average vertical shear on the portion of the beam $(x_2 - x_1) = s$.

Or,—The difference in moment between any two points along a beam is equal to the product of the average shear over the distance between the points, and that distance.

For loads concentrated at points along a beam this law is not strictly true, unless in each case the concentration occurs at a point midway between the transverse sections chosen; but in the case of "concentrated" loadings by beams cast against the girders in concrete construction, and even by loadings on slabs transmitted finally to the girder, the concentration may not be sharply defined, and there is no determinate law of shear variation over such a region. Moreover, as this discussion will show later, the distance s is relatively small where shear is large. Within the limits of actual conditions in reinforced concrete construction, therefore, the above statement may be considered very approximate for the beam loaded with concentrated loads.

From the discussions given in Turneaure and Maurer, "Principles of Reinforced Concrete Construction," pp. 109 and 223, the amount of tensile stress required of a vertical stirrup to resist the shear stress is

$$\frac{Vs}{jd} \qquad (2)$$

in which V is the average vertical shear over the portion s of the beam. The idea of maximum shear intensity on a vertical section of the beam is retained in the above expression.

Since the tensile strength of the stirrup is relied upon to carry the above force, when s is the space between adjacent stirrups, the total strength of the stirrup, $a_s f_s$, would be equal to eq. (2), or

$$a_s f_s = \frac{Vs}{jd}$$

from which

$$V = \frac{a_s f_s jd}{s} \qquad (3)$$

which is the value of the average vertical shear over the portion s of the beam, to be resisted by the stirrup, in terms of the strength of the stirrup and certain dimensions of the beam.

In eq. (1) we have an expression of this average shear in terms of the change in moment along the portion s; so that by substituting in the above, we have at once,

$$M_2 - M_1 = a_s f_s jd \qquad (4)$$

Let it be considered that the portion s be so chosen that section (1), Fig. (1), lies over the left abutment, at which point the moment M_1 is zero. (In continuous girder design section (1) may be considered as lying at a point of inflection, since the moment at that place is

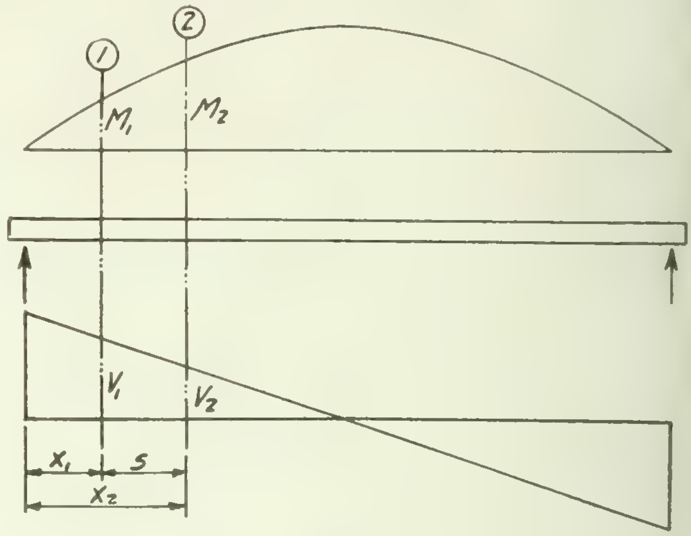

Fig. 1.

zero.) Let the moment increment from zero to M_2 be called M_i. Then from eq. (4),

$$M_i = a_s f_s jd \qquad (5)$$

It is to be noted that this moment increment represents the value of the adopted stirrup to resist the vertical component of diagonal tension over the portion s of the beam. Again, it should be clear that for any given stirrup of area a_s and of fiber stress f_s, the moment increment M_i varies directly with jd, a value dependent upon the characteristics of the beam; and that for a given beam and the given stirrup, the moment increment is a constant, irrespective of where the region s is chosen along the beam.

From values given in tests published in "Principles of Reinforced Concrete Construction," it may be noted that the safe working shear stresses are about three times as great in a reinforced concrete beam as when the beam is not reinforced. We may say, therefore, that the concrete will be permitted to carry one-third of the shear, and the remainder will be cared for by the reinforcement. Eq. (5) then becomes

$$M_i = 1.5\, a_s f_s jd \quad \text{(Vertical Stirrups)} \qquad (6)$$

If the stirrup is inclined at an angle θ to the horizontal, then,

$$M_i = \frac{1.5\, a_s f_s jd}{\sin \theta}$$

And when $\theta = 45^\circ$

$$M_i = 2.1\, a_s f_s jd \quad \text{(Stirrups inclined } 45^\circ) \qquad (7)$$

*Read before the Engineering Society of the University of Wisconsin.

Eqs. (6) and (7) are the final working values of the resistance offered by a single stirrup in terms of an increment of moment.

The chart in Fig. 2 is a graph of the above equations when $j = \frac{7}{8}$, a very common value in rectangular beam design. To use the chart, enter at the left with a given value of d, the depth of the beam; follow across horizontally to the line of the adopted stirrup area; then from this point move up to the fiber stress assigned to the stirrup; and finally passing to the right from this last point, the value of the moment increment for either vertical or inclined rods may be read.

Let us consider the portion of the beam shown in Fig. 3, loaded in such a manner as to produce the moment curve OA. It is desired to reinforce the portion shown with vertical stirrups, keeping in mind the principles just

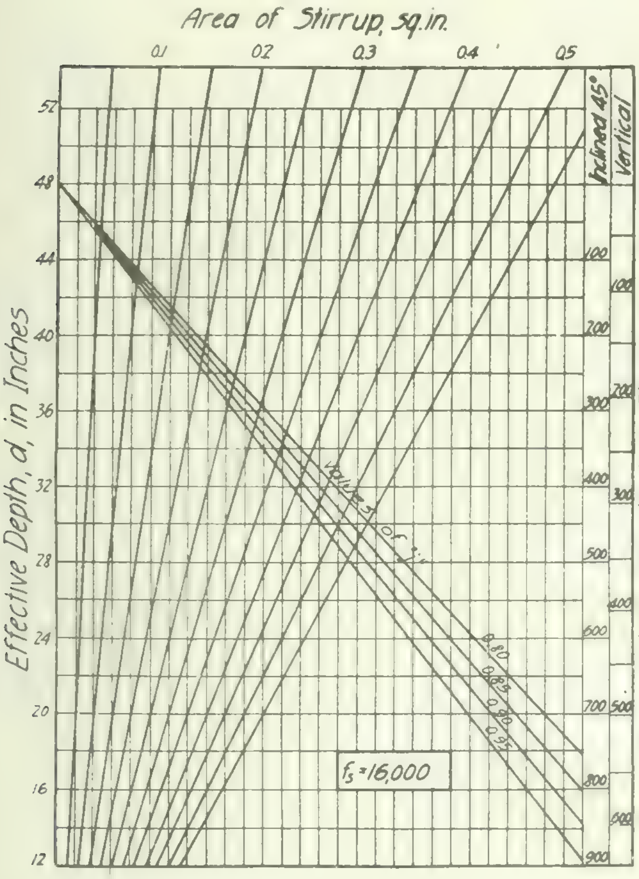

Fig. 2.

laid down. A certain stirrup has been adopted which for this particular beam gives the value of M_1 from eq. (6) equal to the vertical distance shown in Fig. 3a. The first increment intercepts the portion Om of the curve; the second, mn, and so on. Let one of these intercepts, as mn, be projected onto the beam, thereby defining an area ABCD on the diagram of the beam. From the preceding discussion this area is the portion of the beam in which the adopted stirrup will exactly carry the shear. The length s of the portion is seen to vary as the shear varies along the beam. Since the stirrup is required to carry the shear for this portion of the beam it will be placed through the centre of the portion. Likewise, each other portion of the beam defined by the projection of the intercept of M_1 will have a stirrup placed at its centre.

To eliminate the feature of dividing each portion of the beam, the following method is suggested: Lay off, as the first value, $\frac{1}{2} M_1$ (Fig. 3b). Let all other values equal M_1, as before. These increments have m^1, n^1, and so forth, for points of intersection on the moment curve. Let these points be projected onto the beam. Each projection will thus determine the position of the stirrup. This gives very closely the same results as before, since in this case each increment has been bisected, rather than bisecting the projection of the intercept on the curve. However, if the increment is large, as is sometimes the case with bent-up bars, it is likely to subtend a portion of great curvature, in which case the original method is advised. The second method will be found within practical limits for the spacing of vertical stirrups.

The design of a T-beam will now be followed through in detail. The span will be taken as 24 ft. between centres of supports. The thickness of the flange will be assumed to be limited by a 10-in. floor, and the total depth to approximately 3 ft. The following working stresses will govern the design: $f_s = 16{,}000$ lb/in.²; $f_c = 650$ lb/in.²; $u = 80$ lb/in.² (at the supports 50% excess allowed, or 120 lb/in.²); $v = 35$ lb/in.² for concrete and 105 lb/in.² for reinforced concrete. Attention is called to the ratio $\frac{1}{3}$ of the two shear values just given. This is in accordance with the developments of eqs. (6) and (7). The total load on the beam will be taken as 4,000 lb/ft.

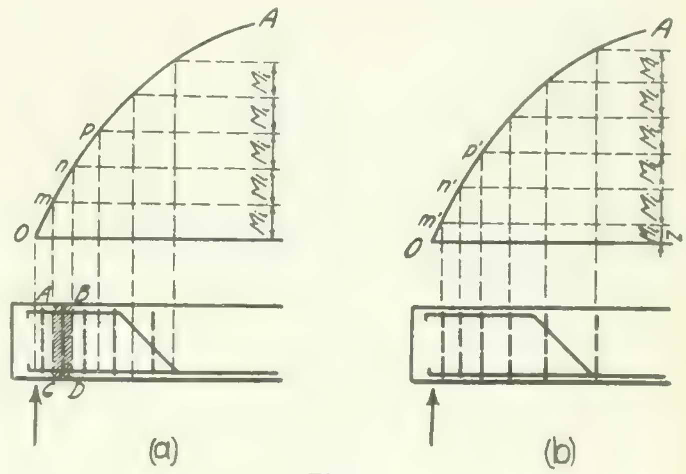

Fig. 3.

The maximum moment is found to be 3,460,000 in. lbs., and the shear at the support, 48,000 lbs. The required web area is 458 in.² or 33 in. deep and 14 in. wide. From Plate X, Turneaure and Maurer, $b = 31$ in., and $jd = 29.2$ in. A_s is found to be 7.4 in.² Eight rods 1 in. square will be used. The value in moment of one pair of rods is computed to be 932,000 in. lbs. The arrangement of the rods in cross-section is shown in Fig. 4c. The width of the web was changed to 15 in. for clearance between rods. The length of rod necessary to develop its tensile strength in bond is 50 in. At the support four rods are necessary to carry the bond stress.

With the above computations available, the placing of the steel in the beam may be done. Fig. 4a shows the bending moment diagram. The resisting moment of each pair of rods is plotted, resulting in the stepped diagram along the exterior of the moment curve. The point of contact of the line with the curve indicates a point of zero stress in the rods corresponding to the zone immediately above the point. This pair of rods may be bent up at this point, therefore, since they are no longer needed to resist moment. It is noted that the four lower rods are required to continue to the end of the beam without being bent up; hence only the upper rods will be bent.

It is proposed to make two arrangements of the steel,—one in which the bent-up rods are intended to carry a

portion of the shear (right side of Fig. 4b), and the other in which the stirrups are designed to carry all the shear (left side of Fig. 4b). The second case, that of all shear being carried by the stirrups, will be treated first. Since it happened that in this T-beam the value of j is $\frac{7}{8}$, it will be permissible to use the chart in Fig. 2. In choosing a value of a_s, the area of the stirrup, a value should be so chosen that the last useful spacing, projected from the last full value of M_1 at the vertex of the moment curve, does not exceed in general $\frac{3}{4}d$, and never more than d. It is possible to estimate by inspection a value of M_1 that will give this final spacing. Entering at the right of Fig. 2 with this estimated value, then over to the line of fiber

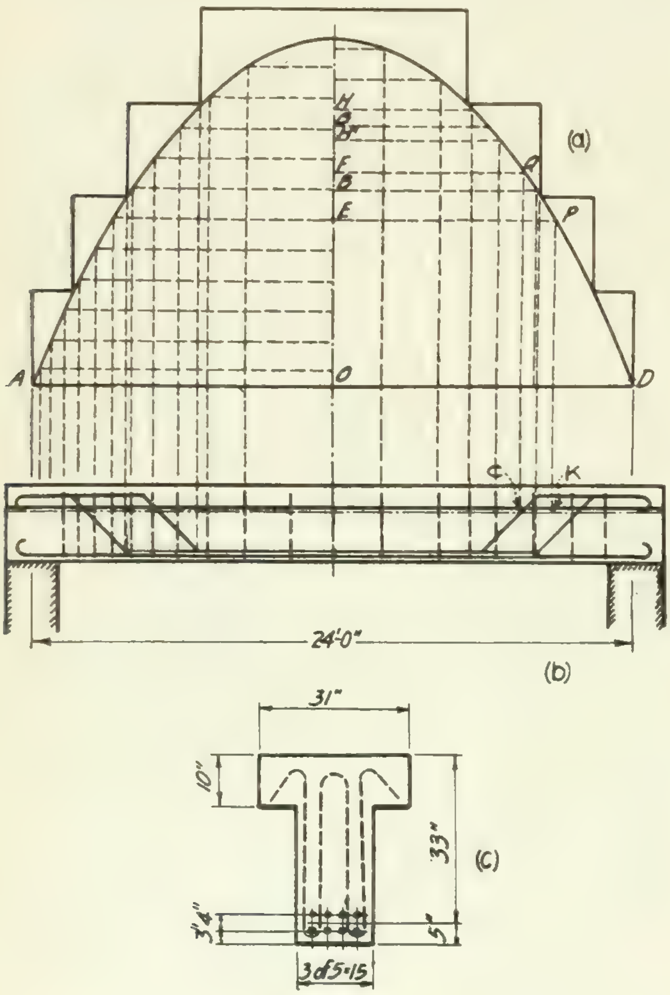

Fig. 4.

stress, and next down to the intersection with a horizontal line from the depth d, gives a tentative value of a_s which may be adjusted slightly to meet the commercial dimensions of the steel. With this corrected value of a_s, and passing through the chart from the left, a final value of M_1 may be obtained very close to the desired value. The adopted stirrup is shown in Fig. 4c.

Following the suggestions relative to Fig. 3b, half of the value of M_1 as determined above is first laid off; then the full value is laid off repeatedly until the vertex of the moment curve is reached. The intercepts on the moment curve, when projected onto the beam, determine the positions of the vertical stirrups.

The numerical value for the $\frac{3}{8}$ in. round stirrup, in terms of the moment increment, is 300,000 in. lbs. They develop sufficient bond to cause a tensile stress of 12,500 lb.in.[2]; and in addition they are hooked and bent to develop the full stress. At the bottom they pass below the horizontal steel.

In the case where the bent-up rods carry a part of the shear, investigation as to their strength in shear resistance must first be made before the point of bending can finally be fixed. Considering a pair of these rods as an inclined stirrup, a moment increment may be determined for the pair from eq. (7). This was found to be 1,960,000 in. lbs. This value is laid off vertically, as OB, Fig. 4b. The distance s corresponding to the pair of rods is much greater than d. The pair is then excessively strong to take the shear; and since the spacing given for bending the rods is also greater than d, the second pair of rods will be turned up, as shown from the bending diagram, while the first pair will be bent up at an arbitrary distance jd toward the centre from the bending point of the second pair. The arrangement is shown in the right half of Fig. 4b.

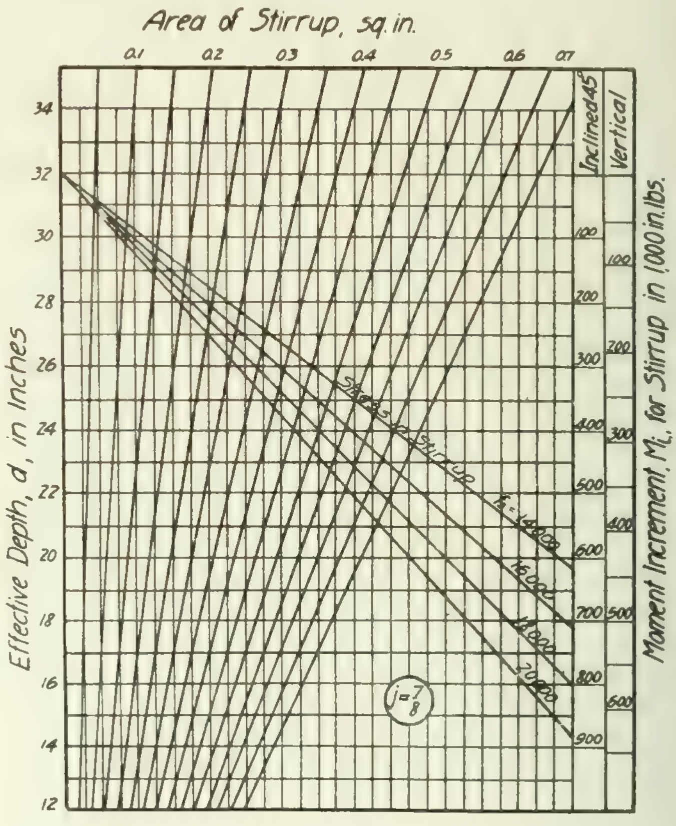

Fig. 5.

Point K represents a point midway between the intersections of the two pairs of bent-up rods with the neutral plane. The projection of K upon the moment curve is P, thereby determining the chord EP. Point C is the intersection of the first bent-up pair with the neutral plane, and its projection on the moment curve is Q, thus establishing FQ. EF, therefore, is half of the actual increment ascribed to the first bent-up pair, on the basis of spacing. EF is then laid off again, as FG, thus completing the increment EG. The portion of the curve from O to G, therefore, is cared for by the bent-up rods. Since OB is the permissible value for one pair, it is seen that they are amply strong to carry the shear, and that their placing was determined by the approximate maximum spacing.

Beginning with G, the stirrup increments are laid off, the first being half value, (GH), as previously explained. The intersections with these and the moment curve determine the positions of stirrups through the region between C and the centre of the beam. It is noted that the stirrup

resulting from H is past the point of bending up the first pair of rods. The space to C is too great in the light of good practice, even though it may be very close to d. Point H^1 is therefore set, with $GH = GH^1$, and an extra stirrup placed. Between this stirrup and the support arbitrary stirrups are placed at approximately $\frac{3}{4}d$ apart, for the purpose of supporting the bent rods during construction.

The rods turned up are carried 50 in. beyond, to develop the required bond. In addition, they are hooked at the ends.

The chart in Fig. 5 shows the solution of eqs. (6) and (7) when j is variable and $f_s = 16{,}000$ lb/in.² A set of similar charts may be made up, each with a different fiber stress. Such a set will apply to both rectangular and T-beams. Fig. 2 applies to nearly all forms of rectangular beams since j varies so slightly; but it is not applicable to T-beams except when j is $\frac{7}{8}$, as was the case in the preceding problem. For T-beams j varies from .82 to .97 and therefore requires a chart that takes this change into account.

LETTER TO THE EDITOR.

Stresses in Lattice Bars of Channel Columns.

Sir,—In response to your letter of March 11th, I would submit the following notes on the ingenious and interesting paper "Stresses in Lattice Bars," by Mr. Pearse, published in *The Canadian Engineer* of February 24th, 1916:

(1) If Sc is the stress at which the material will be crushed, which may be inferred from the three lines at top of page 274, S_1 will be larger than 16,000 lbs. per square inch, the base stress used in Equation 3. In Proceedings of the American Society of Civil Engineers of December, 1915, I find tests showing unit ultimate strength in columns running as high as 45,000 lbs. per square inch. It is presumed that the base stress in the columns should be assumed as the utmost which they can carry, say, from 30,000 to 50,000 lbs. per square inch, for it is at this time when we are interested in the behavior of the lattice.

(2) In the third paragraph, page 274, it would appear that the total stress in the more highly stressed column should be $K\frac{A}{2}$, and not $2K\frac{A}{2}$. Note that S_1 is the base stress, when the added stress due to bending is K and not $2K$. The stress K is added to the stress S_1 in one channel and subtracted from the stress S_1 in the other.

(3) In Equation 3 the quantity $\frac{1}{12{,}000}$ in the denominator seems to be somewhat arbitrarily selected. In Merriman's "Mechanics of Materials," dated 1905, I find, on page 202, for the Rankine formula $\frac{1}{25{,}000}$, $\frac{1.78}{25{,}000}$ and $\frac{4}{25{,}000}$ given as the constants which meet average results in fixed, fixed and round, and round end columns. Again, on page 212, I find for the Ritter formula, which reduces to the Rankine when one constant replaces a theoretical expression, the factors $\frac{1}{34{,}000}$, $\frac{1.78}{34{,}000}$ and $\frac{4}{34{,}000}$. The Dominion Government Specifications of 1908 use $\frac{1}{9{,}000}$, $\frac{1}{12{,}000}$ and $\frac{1}{16{,}000}$, which are, of course, supposed to be conservative.

(4) The table gives only one distance apart for each channel pair, and the r given is that for the strong way of the channel itself. A round end condition is one that one does not expect to find in practice; using sines of two or three times the size used in the table, as indicated at bottom of first column of page 274, would produce other results. As to the width of lattice bars chosen, one may find them a bit large for the smaller sizes of channels; the Dominion Government Specifications require a width of $1\frac{3}{4}$ inches for lattice on 6-inch channels, which exceeds ordinary practice in building work.

(5) Equation 7 predicates a column of, say, $200\frac{l}{r}$ and over; Johnson says the Euler formula applies from $150\frac{l}{r}$. The results are applied to columns of less than this length.

(6) Equation 18 does not follow from Equation 17.

In the Engineering News of October 3, 1907, will be found a solution of lattice bars by Mr. A. M. Meyers. In the same number is an article of interest by Mr. Pritchard, suggesting, *inter alia*, 3% of axial stress to be taken in lattice.

Mr. Modjeski states in Engineering Record 68, page 356, that in the new Quebec Bridge lattice take a shear of 2% of the axial stress.

In the Quebec Bridge Commission report are some very interesting calculations on lattice theory. If this report is not at hand, it may be found in part in the Engineering Record of April 18, 1908.

I regret that I do not have at hand Bulletin 44 of the University of Illinois. In the Engineering News of March 16, 1911, there is, however, a summary of this bulletin. Here I read that the stresses in lattice bars were very variable as between different bars; and the authors, Talbot and Moore, are quoted as concluding: "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations, or on data now available."

Mr. Pearse's theoretical solution of this annoying problem is suggestive and very interesting. I fear, however, that the problem is one of which the complete solution is not in our possession. The same may be said of column formulæ. We can, of course, make satisfactory designs, but the perfect theory and the perfect practice seem still somewhat doubtful.

C. M. GOODRICH,
Designing Engineer, Canadian Bridge Co.

Walkerville, Ont., March 14, 1916.

[In our issue of February 24th we published an article by William Worth Pearse, city architect of Toronto, dealing with the derivation of theoretical formula for calculating stresses in lattice bars of columns. The article created a good deal of interest, and we are pleased to be able to publish the above letter containing some further notes on Mr. Pearse's paper, and trust that others of our readers will be disposed to give our readers the benefit of what information they have on this most interesting subject.—EDITOR.]

The Siamese Government, to which one would not generally look for engineering progress, use to a very great extent reinforced concrete poles, both for street and park lighting and for electric transmission lines. The concrete pole is not only more elastic than teakwood, but it is fireproof; it is easily made and fixed, and is, of course, impervious to the depredations of the white ant.

COAST TO COAST

Toronto, Ont.—The villages of Mimico and New Toronto have applied to the Legislature for authority to build a joint water supply.

Victoria, B.C.—J. P. Kean, in a paper read before the Slocan Board of Trade, advocates the establishment of a zinc refinery in Canada.

Prince Rupert, B.C.—The Grand Trunk Pacific will inaugurate its steamer service between this port and Alaskan points on March 30th.

Winnipeg, Man.—Premier Norris will move a resolution asking the Dominion Government to hasten the construction of the Hudson Bay Railroad.

Vancouver, B.C.—Engineer Hueckel reports that Norris McDiarmid & Co. are entitled to $6,474 extra for work done on the Georgia-Harris viaduct.

Carp, Ont.—Engineers of the Hydro-Electric Commission addressed the ratepayers on the question of cost of installing hydro-electric power here.

London, Ont.—A further request for $39,000 for the London and Port Stanley electrification has been granted. This brings the total cost to the ratepayers up to $900,000.

Ottawa, Ont.—In the annual review of the work of the Department of Railways and Canals a great increase in mileage and prosperity of the government railroads is reported.

Calgary, Alta.—City Engineer Craig reports that the treatment of sewage with chlorine gas would cost $23,300 yearly. It is not expected that the council will adopt the proposal.

Welland, Ont.—The Canadian Steel Foundries Ltd., have started operations at their plant here. The 12-in. mill is now in operation and the 22-in. mill will be started very shortly.

Montreal, Que.—The transmission line of the Shawinigan Water and Power Company has been completed to Quebec and power is being delivered to the Public Service Corporation there.

Peterborough, Ont.—It is expected that the Trent Valley Canal between this city and Lake Ontario will be opened for navigation this spring. The total cost of this division will be $7,660,000.

Victoria, B.C.—Work on the new breakwater is progressing favorably. Divers engaged on the Sir John Jackson contract are now working on the granite blocks at the bend of the main arm.

Quebec, Que.—The Quebec Railway, Light, Heat and Power Company has commenced to construct their own street cars. The first product of the new industry will be completed about April 1st.

Ottawa, Ont.—The Town Planning Commission recommends that the suggestions made by Andrew Bell, C.E., in 1901, regarding the prevention of spring floods on the Rideau River be carried out.

Ottawa, Ont.—Comprehensive plans for the beautification, development and re-planning of the Canadian capitol have been presented to Parliament in the report of the Federal Town Planning Commission.

Vancouver, B.C.—City Engineer Fellowes has advised the board of works not to undertake the responsibility of erecting bulkheads in lanes for protecting side cuts, as it is likely to establish a costly precedent.

Victoria, B.C.—Only eight miles of track remain to be finished before the completion of the Patricia Bay branch of the Canadian Northern Railway. Contracts will soon be awarded for the construction of slips on the mainland and Vancouver Island.

Ottawa, Ont.—T. J. Stewart, of Hamilton, is moving to amend the bill of the Ontario Niagara Connecting Bridge Co. by providing that no construction shall be undertaken on provincial property or the lands of the Niagara Falls Park Commission without the consent of the Provincial Government.

Vancouver, B.C.—The city engineer has reported to the council the completion of the contract by the Vulcan Iron Works for the supply of 14-inch main, and the expense the city was put to by reason of the construction of a temporary main to eliminate the damage from the leak at Essondale. The water committee will be asked to report on the whole question of what claim the city has against the contractors.

New Westminster, B.C.—Mr. C. C. Worsfold, resident engineer here for the Dominion Government, who has returned from Ottawa, states that the sum of $15,000 has been noted in the supplementary estimates for the work of carrying on the construction of the Fraser River main channel jetty, the second unit of which is now being built by the Marsh-Hutton-Powers Co. The supplementary estimates, however, have not yet been before the House. Under the Le Baron scheme, the north unit, that now under construction, was designed to be built in three units. The contract for the second unit was let at a price in the neighborhood of $400,000. The third, and longest, will cost probably $500,000, so that the sum put in the estimates, if voted, will only provide for a portion of the third unit, probably enough to continue the work throughout the summer and fall.

FEBRUARY COBALT ORE SHIPMENTS.

The following are the shipments of ore from Cobalt during February, 1916:—

	Tons.
Beaver Consolidated Mining Company	33.73
Buffalo Mines	37.69
Coniagas Mines	84.21
Dominion Reduction Company	220
La Rose Mines	87.08
McKinley-Darragh-Savage Mines	207.85
Mining Corporation of Canada (Cobalt Lake Mine)	122.41
Mining Corporation of Canada (Townsite City Mine)	84.68
Nipissing Mining Company	65.52
Penn-Canadian Mines	35.99
Peterson Lake Silver Mine (Seneca Superior Ore)	105.86
Peterson Lake Silver Mine (Mercer shipment)	17.21
Timiskaming Mining Company	38.92
Total	1,141.15
New Liskeard—Casey Cobalt Mine	29.5
Porquis Junction—Nickel ore	1,026.5

Coal ash contains silica, alumina, iron pyrites and other mineral matter. Depending upon the chemical composition and physical condition, these cause the ash to fuse more or less easily. The temperature at which firebrick will melt is sometimes influenced by the composition of the ash. For instance, a certain ash might melt at 2,600 deg. F. and a certain firebrick at 2,800 deg. F.; but together in a furnace both might melt at 2,500 deg. F.

Editorial

HYDRO-ELECTRIC DEVELOPMENT IN ONTARIO.

An announcement of no mean importance was that made last week by the Honorable G. Howard Ferguson, Minister of Lands, Forests and Mines for the Province of Ontario, to the effect that an agreement had been completed whereby the government takes over the entire business and assets of the Electric Power Company, including all their subsidiary companies, twenty-two in number. Under the arrangement by which these companies come under the jurisdiction of the Hydro-Electric Power Commission of Ontario, it is expected that not only will Central Ontario be served but North Bay and Nipissing District will be able to get the advantages of public hydro development.

It has been said that the strength of any nation can, to at least a large degree, be measured by the intelligence shown in the development of its natural resources. Water power in Ontario as a provider of human necessity is apparently destined to see great development during the next few years and the government is apparently determined that in order to fill the public needs for water power it is in the interest of the whole community that the water powers in the province should be developed as rapidly and as efficiently as possible.

By their very inherent nature, water powers are monopolistic. There is only one Niagara, and while the companies, both public and private, that control the power development possible through Niagara may control the water power of a large territory, a thousand companies could build steam power plants in the same territory.

Ontario is essentially the manufacturing province of the Dominion, and it is fair to assume that there will be a constantly increasing development of power of all kinds for industrial purposes. Present-day industrial and economic standards have made power a public necessity. Water power is a supplier of this necessity, and while the employment of water power is very old, more progress in its use had been made in the last twenty-five years than perhaps in all the years that have gone before.

Statistics show that we have coal for many years to come, but they also show that the economical deposits are being worked first and as the coal becomes deeper the cost of production increases very rapidly.

The popular notion is that when a water power is well constructed it costs so little to run that the power developed is the cheapest in the world. The facts do not appear to support this view, but rather disclose the fact that steam power is, under certain conditions, a very keen competitor of water power. Steam power is movable, flexible; water power is inflexible and not portable. Steam power can be taken to the factory in small or large units as may be required; on the other hand, the factory must, to a large extent, be taken to the water power.

Irrespective of the relative value of water power as against steam power, the fact remains that the announcement recently made by the Ontario Government is far-reaching in character and is significant in that it indicates that the government recognizes the importance of seeing to it that every section of the province is served so far as it is in its power to do so.

By this step it is said that many power developments will be made possible which have heretofore been held for a nominal rental, and unrelated as they should be to the industrial life of the community.

AN INTERESTING REPORT.

In this week's issue we publish an abstract of the report of the Quebec Roads Department, which was issued only a few weeks ago. In connection with this report there is one feature of it that should be specially noticed; that is the expedition with which it has been prepared and placed in the hands of those for whom it is designed. Hon. J. A. Tessier, Minister of Roads, and his associates are to be complimented upon the completeness of the report and the promptness with which it has been issued.

There are some very interesting features in connection with the report as indicating the very remarkable development that has taken place during the last twenty years in the good roads movement so far as Quebec is concerned. The table which is printed at the end of the article in this issue calls attention to the remarkable fact that whereas in 1895-96 the sum of money expended for good roads in the Province of Quebec was $30.20, the amount of money spent in the year 1914-15 was $6,140,273.13. This statement tells its own story.

PREPAREDNESS FOR INDUSTRIAL DEVELOPMENT.

A bill has been brought before the Ontario Legislature which is to create "The Trades and Labor Branch." By the establishment of this branch of the Public Works Department now it should be fully organized and ready to take its place as the representative of labor throughout the province, and will be in a splendid position to render great service when the great army of workers return from Europe. The branch is to be presided over by a superintendent who will have the powers and duties usually assigned to a deputy head of a department. Officers engaged in the administration of any of the laws relating to matters assigned to the branch will make their reports to the superintendent and will carry out instructions as directed by him.

For the present the branch will have charge of the administration of The Bureau of Labor Act, The Stationary and Hoisting Engines Act, The Building Trades Protection Act, The Factory, Shop and Office Building Act, and The Steam Boilers Act. Among other things, the duties of the branch will be to look after the general welfare of the industrial classes.

Another very important duty which will be assigned to this branch will be to enquire and report as to the establishment of new industries in Ontario, in any case where by reason of the production of raw material for such industry in Ontario, or the immigration of persons skilled in the particular industry or other circumstances which make it appear that such industries can be profitably carried on.

Along these lines the branch will be in a position to render a real service to engineers and engineering interests for, with the coming of new industries more work will be created for the engineer and an increased demand for technically trained men is bound to follow. This will relieve the situation which now exists in that a great many technically trained men have been forced to find new fields for their endeavor or else fit themselves for some vocation which is in demand at the present time. New industries will create a state of affairs which the technician has long looked forward to—he will be in demand, his status will be improved and incidentally his services will command a rate of remuneration more in keeping with the dignity of his profession. Similar bureaus in other provinces and a system of interchange of services and privileges would be in keeping with the development of the country as a whole and prepare us for the great industrial development that is coming.

PERSONAL.

W. H. FAIRCHILD, of Brantford, has been appointed city engineer of Galt, Ont.

F. W. EVANS has been appointed manager of the Toronto sales branch of the Canadian Fairbanks-Morse Company.

LORNE THOMPSON, head of the Stores Department of the C.N.R., has joined the staff of the munitions board at Ottawa to look after the transportation end of the board's business.

THOMAS HENRY, chief engineer of the Interurban Electric Company, has resigned that position and associated himself with the sales department of the Toronto Electric Light Company.

G. A. MOUNTAIN, chief engineer for the Board of Railway Commissioners, took part in the discussion at the monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers on March 9th.

C. A. BELL, who went overseas with the 2nd Field Co., Canadian Engineers, has received a commission. Lieut. Bell is a graduate of S.P.S. and was a mining engineer at Copper Cliff before enlisting.

J. McCORMICK, for the past nine years connected with the sales department of Mussens Limited, Montreal, has resigned, having accepted a similar position in the machine tool department of the Canadian Fairbanks-Morse Co., of Montreal.

ERNEST LANE, who has been acting local manager for the West Kootenay Light and Power Company for some time, has assumed a similar position at Trail, B.C., where the smelting and refining plant of the Consolidated Mining and Smelting Company is situated.

OBITUARY.

WM. SANDERSON, who was a mining engineer at Cobalt, has been killed in action in France.

The Swedish state railways have been making experiments with peat as fuel for locomotives. The peat is used in the powdered or pulverized form, and it is stated that locomotives using the fuel can haul as heavy trains and make as good speed as locomotives using anthracite coal. The railway directors have decided to undertake the development of this kind of fuel. Two methods will be followed. Two experts have been requested to give complete estimates of the cost of preparing a certain bog and the running expenses with the respective methods

THE TORONTO BRANCH OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

The regular monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers was held in the society's rooms at the Engineers' Club, 90 King Street West, on Thursday, March 9th. The meeting was devoted to the discussion of proposed amendments to the present by-laws as formulated by the committee appointed in 1915 to consider this matter. While the attendance was not what the importance of the subject should warrant, a very interesting discussion took place, and many good suggestions were made. A stenographic report of this discussion will be available in a short time for members wishing to consult it.

PERSONNEL OF COMMITTEES OF TORONTO BRANCH, CAN. SOC. C.E.

At a recent meeting of the executive committee of the Toronto Branch of the Canadian Society of Civil Engineers, the following members were appointed to the several working committees named below:—

Roads and Pavements.—M. A. Stewart (chairman), S. G. Talman, G. G. Powell, H. S. Van Scoyoc, W. Huber. Subject—Investigation of sand for concrete highway construction.

Steel Bridge Specifications.—A. H. Harkness (chairman), Frank Barber, H. L. Steenbuch, David Molitor, Thos. Taylor. Subject— Steel highway bridge specifications.

Sewage Disposal and Sanitation.—A. F. Macallum (chairman), P. Gillespie, W. Chipman, F. W. Thorold, J. H. Nevitt. Subject—Report on commercial success of treating sewage by aeration.

General Clauses for Specifications.—W. Chipman (chairman), E. W. Oliver, E. L. Cousins, Wm. Cross, D. Molitor. Subject—To consider last year's report and suggest modifications if desirable.

Reinforced Concrete.—Peter Gillespie (chairman), Frank Barber, A. W. Connor.

New Members.—J. R. W. Ambrose (chairman), H. E. T. Haultain, A. F. Macallum, G. A. McCarthy, J. H. Curzon.

Legislation Committee.—E. W. Oliver (chairman), J. G. G. Kerry, H. E. T. Haultain.

Power Plants.—L. M. Arkley (chairman), A. A. Bowman, Peter Bain, E. T. J. Brandon, F. G. Clark, A. G. Hill, Jas. Milne, A. L. Mudge. Subject—Uniform steam boiler specifications for the Dominion of Canada.

Hydraulics.—N. R. Gibson (chairman), T. H. Hogg, H. G. Acres, E. C. H. Dowson, C. L. Fellowes, D. Molitor, Wm. Cross. Subject—To continue work of last year on a standard specification for cast iron water pipe.

Track.—E. G. Hewson (chairman), A. F. Stewart, A. L. Hertzberg, F. B. Goedike. Chairman to choose work to be done by committee.

Library Committee.—A. L. Mudge (chairman), W. A. Hare, A. A. Bowman, Fraser F. Keith.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

Volume 30. Toronto, March 30, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

STRACHAN AVENUE BRIDGE, TORONTO

DESCRIPTION OF A BRIDGE IN WHICH THE DESIGN OF THE FLOOR SYSTEM PRESENTS SOME NEW FEATURES

By E. M. PROCTOR, B.A.Sc.,
Structural Designer, Railway and Bridge Section, Department of Works, City of Toronto.

THE Strachan Avenue bridge is over the Grand Trunk Railway, Toronto-Hamilton line, at the foot of Strachan Avenue, Toronto. This bridge replaces an old timber truss bridge which was completely worn out. There are several points in the design of the structure which may be of interest.

The bridge is a through plate girder type with a reinforced concrete floor and has all members below the floor encased in concrete. The abutments are 92 ft. 4½ ins. face to face of back walls and the bridge is 57 ft. 6 ins. centre to centre of handrails. There are two roadways 18 ft. 3 ins. curb to curb, and two 6-ft. (in the clear) sidewalks. The girders are 21 ft. 9 ins. centre to centre. The loading specifications (Fig. 2) are the Standard City of Toronto Class A. Provision was made in the steelwork for future possible street railway traffic, but no rails were laid.

Fig. 1.—General View of Bridge, Looking East.

In a bridge of this type it is a difficult matter to obtain anything but a plain appearance. However, there are several features which very much improve the appearance and do not add very materially to the cost of the bridge. The 16-inch panelled facia girder along the front and the ornamental handrail (Fig. 9) both help in this respect. Fig. 1 shows a general view of the bridge, looking east.

The old timber bridge had head room clearance of 19 ft. 1 in. and space for four tracks. The new bridge gives a head room of 22 ft. 6 ins. and space for six tracks. This increase in height and width necessitated the raising of the grade on Strachan Avenue about 7 ft. at the north end of the bridge. On account of possible land damages, it was essential that this elevation of grade (on Strachan Avenue) should be kept to a minimum. To obtain this, a suspended floor beam type of floor was decided upon, with which it was possible to design a floor 2 ft. 3 ins. from top of paving to underside of floor. This type is only permissible where the tracks below are definitely located. The floor beams are placed so as to come centrally between tracks. This arrangement can be clearly seen in several of the accompanying views.

Fig. 3 shows clearly the structural details of the floor beam. The end connection angles rivet to a web plate which projects down through the bottom flange plates of the girder (Fig. 4), the notch allows for the outstanding flange of the girder and the holes in the gusset plate connect to a 7" x 3½" x ½" stiffener angle on the girder. The stringers bear on the brackets shown on the web of the floor beam and for added general stiffness are also connected to the web with a pair of clip angles.

The centre girder, which weighs 36½ tons, is made up of a web plate 120" x ⅜" and flanges as follows: Two L's 8" x 8" x [illegible]" with four 20" x 11 16" cover plates on top flange and two 20" x ¾" and two 20" x 11/16" cover plates on the bottom flange. The added section in the bottom flange takes the place of the section lost by cutting holes in the cover plates for the webs that carry the floor beams (Fig. 4). The outer girder, which weighs 26½ tons, is made up of a web 96" x ⅜" and flange of two L's 8" x 8" x ¾" with two 18" x ⅝" and one 18" x ½" cover plates on the top flange and three 18" x ⅝" cover plates on the bottom flange.

The girders bear on cast steel bed plates. At the expansion end the sliding takes place between two phosphor bronze plates, one inset into the shoe plate and the other into the bed plate. Fig. 5 shows a view of the top of one of the bed plates and illustrates how the inset is machined. A groove on each side is first planed across the casting

and then the casting is turned on the plane and the space between the grooves is planed out.

The phosphor bronze plates were shipped loose and were put in place just before the girder was lowered into position. Some time would be saved in the field if a couple

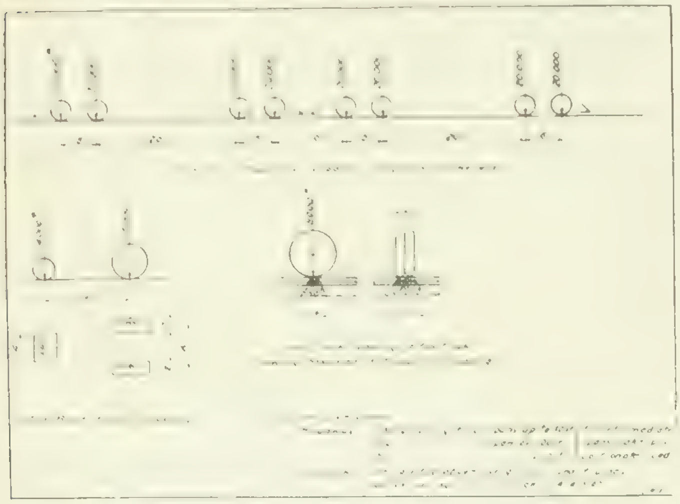

Fig. 2.—Standard Loading Specification, City of Toronto.

of field countersunk tap screws were put in each plate in order to hold them in place during erection.

Fig. 6 shows the method used in the erection of the girders. A gallows frame was erected over one of the tracks and the girders were lifted from the flat cars and then swung into place. By reason of the fact that it was impossible to place the gallows frame in the centre of the span on account of the layout of the railroad tracks, some means had to be adopted to properly balance the girders as they were being lifted. For the first girder, two boxes of steel punchings were used as a counterweight (Fig. 6) but in the other two girders the locomotive crane was

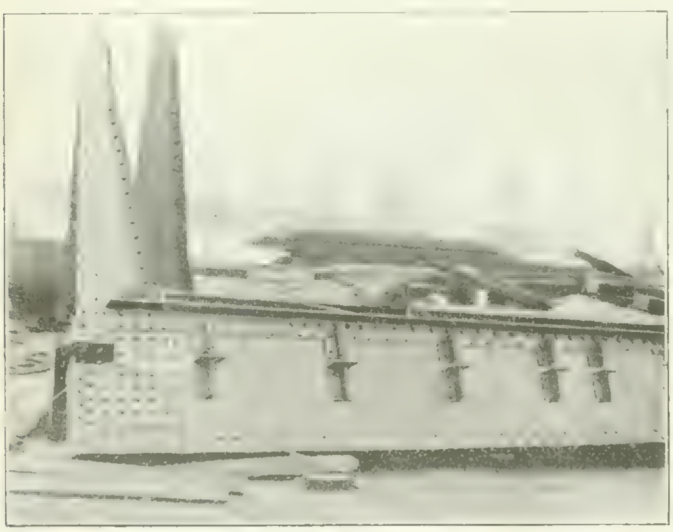

Fig. 3.—Floor Beam.

used to keep the balance by taking a lift on the long end of the girder. This was found to be a much quicker method. The hoisting power was supplied by a steam hoisting engine and a locomotive. The erection was carried out without interrupting traffic on the railroad.

The steel encased in concrete was not painted; the other steel was given a shop coat of paint, made up of 25 lbs. pure red lead to one gallon pure boiled oil. Two coats of paint were applied in the field, the specifications for their composition being as follows: 220 lbs. of pure lampblack ground in pure raw linseed oil (the proportion of lampblack by weight shall be not less than 25 per cent. nor more than 30 per cent. of the mixture); 49 gallons

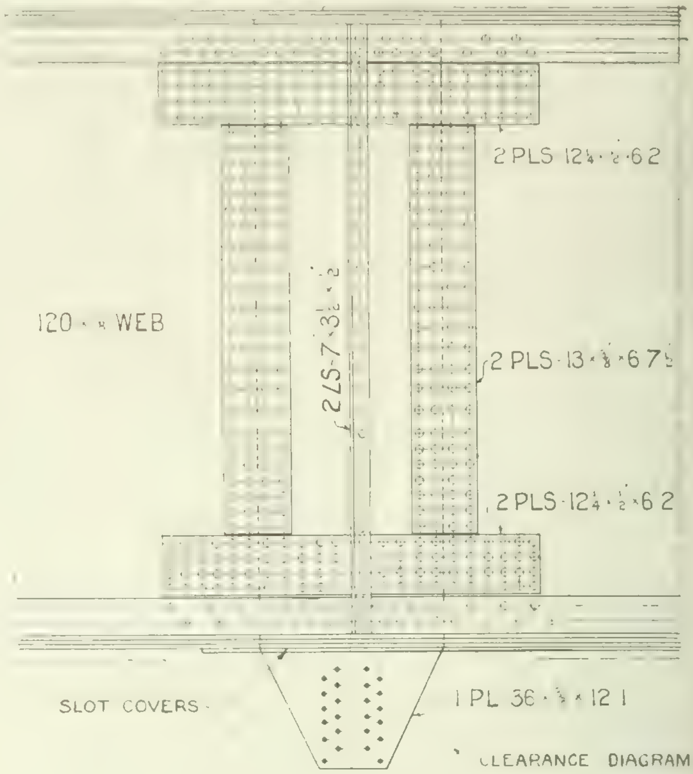

Fig. 4.—Detail of Web Splice and Web Hanger Plate.

asphaltum varnish; 15 gallons pure raw linseed oil; 15 gallons turpentine-japan drier. The paint shall weigh 8 lbs. 2 oz. per gallon. The various ingredients of the

Fig. 5.—Cast Steel Bed Plate, Showing Inset for Bronze Plate.

asphaltum varnish and turpentine-japan drier were carefully specified.

The floor of the bridge is supported on a 7-inch reinforced concrete slab. The pavement is 4-inch creosoted wood block laid on a ½-inch mortar bed. The slab is waterproofed as follows: First, the surface of the concrete slab was thoroughly cleaned and given a coating of hot

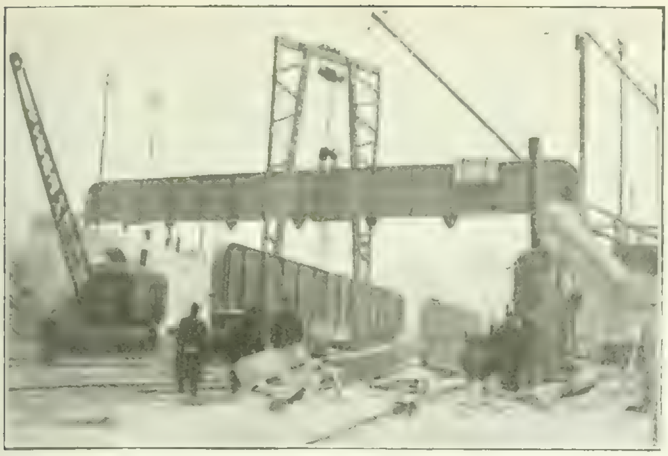

Fig. 6.—Erection of Girder.

asphalt; on this was laid two ply of 8-oz. burlap and then two ply heavy asphalt felt, each layer being well swabbed on with hot asphalt. These fabrics were laid in alternate layers and in such a manner as to permit the layers to break joints and be free from folds or pockets. On top of this was laid a layer of building paper and then $1\frac{1}{4}$ inches of asphalt mastic. The building paper was used in order to avoid injury to the waterproofing by the hot mastic.

As stated before, all the stringers, floor beams, sidewalk brackets and a portion of the girders are encased in concrete. Square twisted steel was used as reinforcement and No. 2-13-15 expanded metal for beam wrapping. Fig. 7 shows the cross-section of the floor. The hollow terra-cotta tile shown are used for the purpose of decreasing the dead load on the girders. The load taken off the centre girder by this means amounts to 7 square inches of flange section which is quite an item in a heavy girder. The cost of this tile work, in place, is slightly cheaper than concrete. The total dead load taken off the bridge by this means is estimated at 200,000 lbs.

Two factors governed the design of the abutments; first, bedrock is 13 feet below base of rail, and second, the main Garrison Creek storm overflow sewer runs under the abutment. This sewer is 12 feet wide outside and

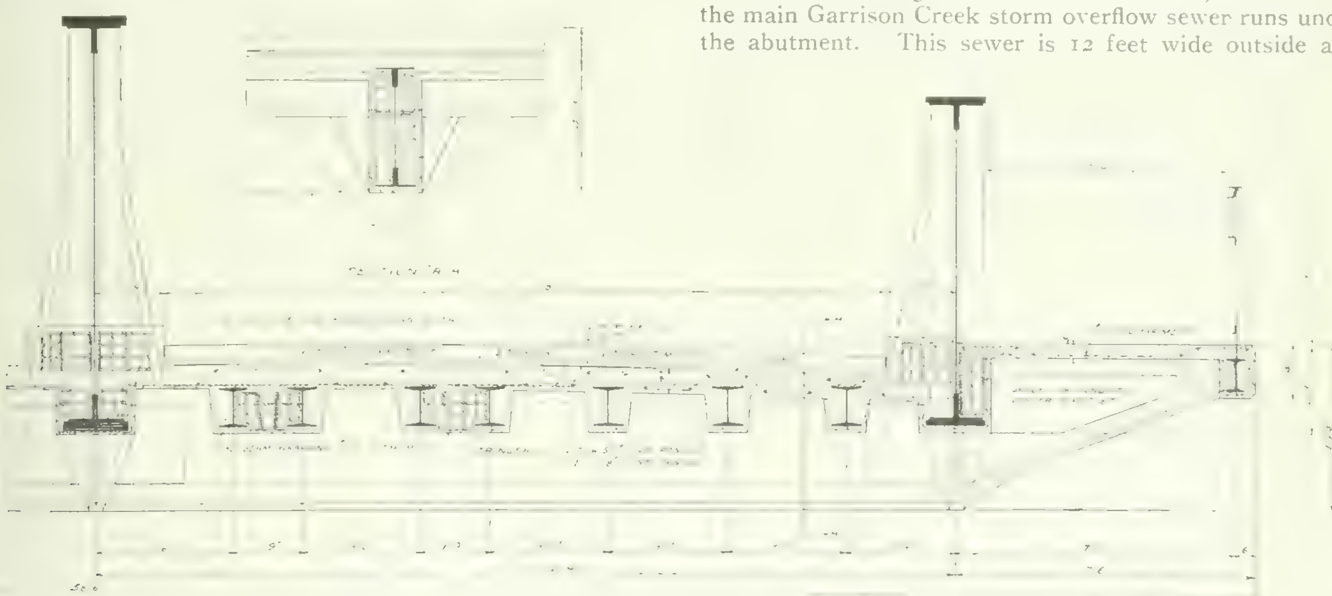

Fig. 7.—Cross-section of Floor.

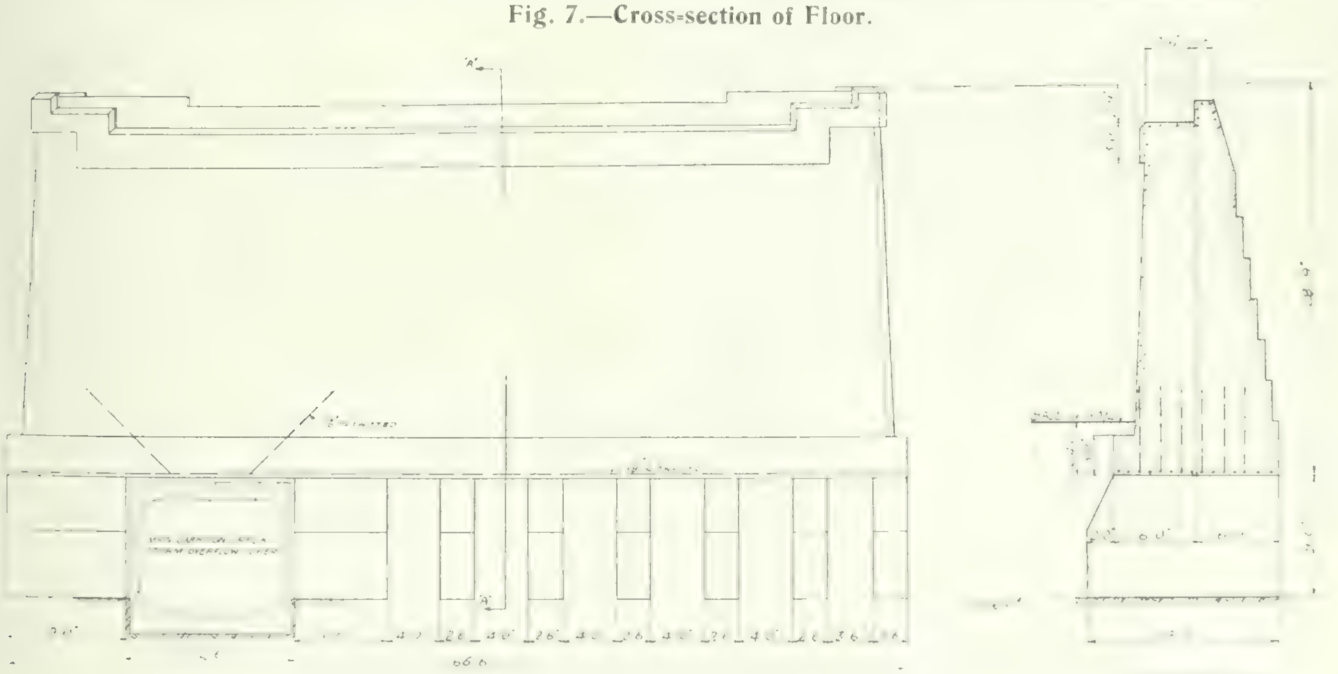

Fig. 8.—Elevation and Cross-section of North Abutment.

rests on the rock. The type of abutment decided upon was a gravity section resting upon 30-inch walls at 6-ft. 8-in. centres carried down to rock and having the main wall reinforced to carry over the sewer. Fig. 8 shows the elevation and a cross-section of the north abutment;

Fig. 9.—Ornamental Handrailing.

the south abutment being similar. The 2-inch space around the sewer was filled with well-packed sand. The reinforcing rods are 1⅛-inch square twisted steel. This type of abutment proved very economical.

The contract price for the concrete floor, waterproofing, abutments and about 400 lin. ft. of retaining walls for the north approach was $33,206.38, and for the steel

Fig. 10.—Girders as Delivered Just Before Erection.

work, $11,046.69, which makes a total cost of $44,253.07. These figures do not include cost of paving, lighting and filling of approaches.

The bridge was designed under the supervision of G. A. McCarthy, engineer of the railway and bridge section, Department of Works, City of Toronto. C. J. Townsend was contractor for the concrete work and the Dominion Bridge Company had the contract for the steel work.

An announcement made by W. Rathbone Smith, the general manager of the E. D. and B. C. Railway, states that the head of steel on the Grande Prairie branch railway is now at mile 40, or only 10 miles from Grande Prairie city, thus tapping the heart of the Peace River district.

REINFORCED CONCRETE IN SEWERS.*

About the year 1900 reinforced concrete had been taken up in many fields of construction and applied to long-span arches, and the advantages of its use in sewer construction were soon appreciated. During the next five years, many examples of concrete sewers are found, although with a few exceptions the reinforcement consisted of wire mesh or expanded metal and there was an evident tendency on the part of the majority of engineers to use rather heavy sections similar to the plain masonry types. A few examples are also found of extremely radical designs involving very light sections heavily reinforced. These two extremes suggest the difference between the sewer engineer adapting his designs to reinforced work and the concrete expert breaking into the sewer field. In the last 10 years, all of these ideas have been through the melting pot, and we are beginning to find certain standard types of reinforced concrete sewers used generally. These are the horseshoe type varying in proportions from the semi-circular to those of about equal height and width, and the elliptical, usually constructed as a five-centered arch. Of exceptional advantage under certain conditions the box or slab section is often employed, but under average conditions it is less economical than the other types. The circular sewer is difficult to construct in what is known as "monolithic" work, that is, if built in place, but the circular reinforced concrete pipe developed along other lines has become standard construction in size up to about 8 feet. It is unit work and may be considered as a factory product, and for that reason a much more satisfactory concrete can be secured through its use than is generally obtained in monolithic work.

In many cases, the shape of the sewer will be controlled by local conditions. In wet ground the invert must be kept as high as possible and a broad, shallow section results. For such cases the semi-circular shape is the most economical, and, in fact, is about the limit of distortion in that direction, as computations show that little further decrease in height can be obtained by adopting a wider, flat segmental arch. For such extremes where the semi-circular is not satisfactory, it is possible to design a box section, and if necessary, a multiple box, though this latter should always be compared with a similar multiplication of normal arches before being adopted.

Where the sewer is deep, and in particular, if in rock, there is usually economy in making the heights of the section greater than the widths, and if in deep rock cut, it is possible to use plain concrete sides and a flat arch abutting on the rock.

Under average conditions the most economical section is undoubtedly one approaching nearly to the circle; that is, having width and height about equal, but on account of the difficulty of securing satisfactory construction with a semi-circular invert, a segmental invert (usually a 45 to 60-degree segment) has been common.

For loads due entirely to earth pressure and for sewers through fully developed territory where the loading can be definitely determined, arch sections of the semi-elliptical or similar types can undoubtedly be used to advantage, as the concrete can be worked in direct compression for the normal load and reinforcing put in to allow for unusual conditions. But where the loads cannot be predicted with reasonable accuracy or where extreme loads of opposite character must be provided for, there will be little difference between the semi-elliptical

*Extracts from a paper read before the American Concrete Institute by W. W. Horner, Engineer Board of Public Service, St. Louis, Mo.

and semi-circular sections, and there is undoubtedly a prejudice in favor of the latter.

The great advantage of the reinforced arch for use in sewer construction lies in the economy in material. In large sizes, 8 feet or over, the reinforced concrete sewer requires only from 60 to 80 per cent. as much masonry as the "gravity" type. Also, where the amount of concrete per foot is sufficient to warrant an efficient plant, the unit cost of the concrete should be somewhat less than that of good brick masonry. In addition to the saving in masonry, there is usually an accompanying difference in excavation, and in deep work this may be a material consideration. Finally, there may reasonably be a difference in required size of sewer due to the greater smoothness of good concrete work, which amounts to between 5 and 10 per cent. reduction in mean diameter.

There can be no question that reinforced concrete is the natural engineering solution for the problem of large sewers. If reasonably designed and carefully constructed, it gives the best and cheapest sewer. In the hands of a designer not thoroughly familiar with the conditions surrounding sewer construction and maintenance, or of a contractor not experienced in reinforced concrete work, it is likely to be a dangerous material and it is a much too common occurrence that work is handled under just these conditions. The fact that many of these sewers are built by contractors whose whole experience has been with massive masonry, has not tended to add to the safety of the finished work.

When the excavation is complete, the invert is concreted. In rock or in dry ground, this can be done efficiently, but if water or mud is present, a portion of the concrete is sure to be unsatisfactory. With very bad bottoms, it is often necessary to place a raft of extra concrete and allow it to set before attempting to place reinforcement. If such conditions appear possible, good practice will provide for this work in both specifications and estimate and many reasonably provide for underdrains to relieve the new concrete of damage from water flowing from the trench ahead. Unless the specifications are to provide that the work is to be expensively delayed, it should be noted that there will be quite an amount of working over and across the new invert while the concrete is setting and exposed bars left for splicing are likely to be bent and jarred and their bond value in the invert concrete decreased. Also, because of these stub bars, it is usually impracticable to protect that portion of the invert from dirt and rubbish. While it is generally the custom to leave the sides of the invert rough to furnish a bond with the arch, it is an open question whether the finishing of this concrete smooth is not the lesser evil, as it can then be thoroughly and efficiently cleaned before additional concrete is laid.

Before the arch forms are set, it is necessary to remove cross bracing up to the crown level, and it must be replaced with verticals bedded in the new invert and cross-braced above the crown. Even with the most careful work, this will produce some disturbance with the sides of the trench and may even allow a bulging of the side plank enough to protrude within the neat measurements of the sewer. To widen and rebrace the section from the surface down may be expensive and hazardous as well as disorganizing, and the engineer often faces the problem of modifying the section instead. Instances can be recalled where the contractors have even asked permission to fill the whole trench to the top of the sewer with concrete at their own expense, rather than to attempt the re-excavation, and the construction engineer must be able to decide whether the deficiency in thickness at the sides can be compensated in this manner.

Collapsible steel forms are usually favored for the arch, and if kept well cleaned and oiled, produce the best interior surface, but well-made wooden centres carefully planned will result in more satisfactory work. The choice will usually depend on the contractor's organization and schedule, as greater progress with one outfit can be secured if the collapsible forms are used.

Under the conditions prevalent in this work, the setting and holding of the arch reinforcement in accurate position is especially difficult and the importance of accuracy is rarely appreciated by foreman and laborer. When properly set, the rods are difficult to hold during concreting, as it is often necessary for the men to stand on the reinforcing while spading the concrete. The cost of special chairs or holders for the reinforcement is usually well warranted.

The placing of the concrete is made especially difficult because of the double mat of reinforcing bars, which tend to break up the stream of concrete and to cause a separating out of the aggregate. The concrete is also likely to be lowered in quality by an almost unavoidable leakage of water. The concrete is also contaminated to some extent by earth and rubbish knocked from the surface into the forms. There occurs, also, even in the best regulated work, certain small slips of earth from between the side planking, and it is possible that portions of the clay or loam may be churned into the concrete before it can be cleaned out from the tangle of reinforcement.

In view of the unavoidable construction contingencies inherent in this class of work, the writer would recommend to the designer the following prescription:

1. Use the best grade of concrete and considerable excess of mortar.

2. Do not work concrete at more than 450 pounds, unless the construction conditions are to be exceptionally favorable.

3. The concrete cover outside of the steel should be at least 2 inches.

4. Use a minimum thickness of concrete of about 9 inches unless the work is close to the surface, or is to be built under very favorable conditions, and increase this minimum and also the cover over the steel if the conditions are likely to be very unfavorable.

5. Specify the setting of the reinforcement with especially designed holders. These might be made of cast iron and left in the concrete.

6. If there is any possibility that the trench will be very wet or mucky, provide for a sub-base of concrete and provide means of keeping the trench work away from the work if possible.

7. To secure a concrete that will flow into place with the least assistance, a specification for a $2\frac{1}{2}$ or a 3-minute mix should be seriously considered, as might also the use of hydrated lime. This would naturally result also in a denser and more waterproof concrete and might be a very considerable factor in prolonging the life of the reinforcement.

8. Provide for a lining of vitrified brick for the invert, or at least provide an excess internal area to allow for such a lining at some later date. This is of more importance in maintenance than in construction, as under average conditions it is easier to obtain a reasonably smooth invert with the brick than to attempt to finish the concrete itself.

9. Specify cold weather methods. Concrete can be placed satisfactorily and economically at even a zero tem-

perature, if proper precautions are taken. It should be noted, however, that it is quite easy to over-heat the finished concrete and to drive out a portion of the water.

In the St. Louis work, it has been customary to heat the water by turning exhaust steam into the water tank whenever the temperature goes below 40 degrees or whenever there is frost in the materials. In colder weather, steam coils are used in the sand storage piles and often in the piles of coarse aggregate. It is also customary in freezing weather to place salamanders inside the arches and to hang tarpaulins at each end of the unit constructed. The top of the sewer has generally been protected by a covering of tarpaulin or plank, on top of which manure is piled.

The loads to be considered are: First, direct weight of the earth filling; second, horizontal or inclined pressures induced by the weight of this filling and the adjoining earth; third, pressures due to transmitted surface loads.

The relative values of these pressures will depend on the depth and size of the sewer and on the use to which the ground surface may be put.

Vertical Loads.—It is always safe and usually reasonable to design for vertical loads equal to the full weight of the superimposed earth. Recent investigations of small sewers and pipes have shown that, due to some arching action of the earth itself, the full dead weight is not always applied to the sewer. The allowable reduction, however, seems to be of little importance until the depth of the fill is at least equal to the width of the trench and would only amount to about 25 per cent. when this depth is twice the width. The work of Marston and Anderson indicates that for depths of 10 to 15 times the width, only 30 to 40 per cent. of the load is carried by the sewer. For a sewer more than 8 feet in width, the depth of cover will rarely exceed twice the trench width, so that the reductions are hardly worth taking into account. There must also be reasonable doubt whether the gradual settlement does not finally increase the weight on the sewers considerably above the values given.

Horizontal Pressure.—There is so much doubt as to the correct values of horizontal pressures even for a given soil condition, and the pressures will vary so greatly in the different soils that the designer can only attempt to make a safe guess at the correct amounts to be used.

According to Rankin's theory, the intensity of horizontal pressure cannot be less than one-third of the intensity of vertical pressure for a particular depth and in ordinary clay it is customary to consider it as one-half of the vertical. For saturated ground, the earth will approach the condition of a fluid and the horizontal and vertical pressures would be equal.

Surface Loads.—Where sewers are constructed in city streets, the heaviest surface load would be the weight of a road roller, and this might be taken as 15 tons on an area of 5 square feet, at the surface, distributed downward along an angle of 30 degrees with a vertical. At a depth of 10 feet this would approximately be equal to 200 pounds per square foot on an area of 11 x 15 feet, or roughly equivalent to an additional 2 feet of fill. If there are railroads crossing the line of the sewer, or if it seems at all possible that such roads may be built, the sewer should be designed for locomotive loading in the same way. A fair value for this loading would be 80 tons on an area of 10 x 20 feet at the surface. Distributed as above, this would be equivalent to about 300 pounds per square foot over an area of 20 x 30 feet, at a 10-foot depth and would give the same pressure as 3 feet of additional fill.

For very light covers, these values would, of course, be increased, and it might even be reasonable to provide for impact, but for depths of cover for 6 feet, or more, it is usually satisfactory to treat such loads as additional weight of earth and allow them to increase both the vertical and the horizontal pressures. Allowance for foundations and for piles of material may be handled in the same manner.

Combination of Loading.—For final conditions, that is, after the backfill has reached a state of settled equilibrium, the sewer will be subject to a direct combination of horizontal and vertical pressures. It should be noted that the greatest bending moments in the arch will be due to vertical loads alone. Horizontal pressures usually induce moments of the opposite kind. The combination of vertical and horizontal pressures, therefore, while increasing the direct normal compression in the arch, will give smaller bending moments than those from the vertical loads. While the stress in the arch may finally reach the values derived from a proper combination of the two classes of forces, yet it is quite common for the sewer to be subject only to pressure of one kind during the construction period. Examples of this are as follows:

(*a*) A trench is excavated through hard clay which requires little bracing and will stand vertically for some time. The trench is backfilled with the same material. Then the full weight of the backfill may act vertically on the arch for some time before the sides of the trench finally slip and add also a horizontal pressure.

(*b*) In the example above, the sides of the trench may slip in against the sewer before the backfill is placed, producing heavy horizontal pressure and bending moments of reverse character.

(*c*) A trench through soft ground is held by sheet piling. When this piling is pulled there may be an appreciable time before the earth at the sides closes in and fills the void left by the piling. During this time the vertical loads only will act.

(*d*) In the above example, if the sheet piling is drawn before the backfilling is started, the earth at the sides may move in and produce horizontal pressure with very little vertical load.

Loads of these kinds will only occur while the arch is new, possibly before the concrete has attained more than half of its normal strength. If the design contains a factor of safety of four for combination of pressures, and the concrete is only 10 or 15 days old, the arch would be about on the point of failure for vertical loads.

It would seem, therefore, that the design should provide for vertical loads alone, or at least in combination with a very small horizontal pressure on the arch only (not against vertical side walls). This loading will be critical and from it the dimensions of the concrete and one set of reinforcements will be determined. The arch so determined should then be designed for horizontal pressure in combination with as little vertical loads as may seem possible. From this the reverse reinforcement may be calculated. Finally, it is of interest to compute the stresses under normal combination of the two.

The simplest case of arch design occurs when the sewer is built in a rock cut. In this instance, that portion above the rock may be taken as an arch with fixed ends, provided that the reinforcement extends well below the rock level. Where the sewer rests on rock or other incompressible material, the arch may still be treated as fixed, if sufficient mass is given to the invert to resist the overturning moment in the side walls.

If the sewer is constructed in soft or compressible soil, the whole section, including the invert, should be treated as an elastic bent beam and the loading must include an upward pressure on the invert equal to the total vertical load.

A number of methods have been published for the analysis of the elastic arch. Of these the simplest is that presented in Green's "Trusses and Arches." Professor Green worked out bending moments in the parabolic arch for unit loads. He also presented constants for the semi-circular arch. Green's constants for the semi-circular arch have been extended by Mr. A. E. Lindau (Trans. Am. Soc. C.E., Volume 51), and put into the same tabular form as was originally given for the parabolic arch. Green's analysis is based on a constant ring thickness. It is not correct for the usual case in which the arch increases in thickness from crown to springing line and some idea of the error involved is given in Lindau's paper. Although inaccurate, this method is very convenient, in that by its use we are able to calculate moments directly from the loading without the previous assumption of an arch thickness. For the smaller sewers and not for all purposes and where the variation in ring thickness is not great, it is sufficiently accurate.

In the writer's practice, this method has been developed into a set of formulas applicable to the semi-circular arch. These formulas give the moment at each 10-degree point in terms of the mean radius of the arch and of the depth of fill over the crown. In the more important work, these formulas are used in order to determine approximate dimensions for an arch which is later to be analyzed by one of the more accurate methods. As the accurate methods must be applicable to all shapes of arches and variations in thickness, it is impossible to reduce them to any very simple form.

In detailing the arch from the calculated bending moments, it will usually be found advisable to use two full sets of reinforcement, that is, on the inner and outer face. If it were known positively that reverse moments could never occur, for example, if it were impossible in the case of a semi-circular arch that the horizontal force could predominate, it would be reasonable to omit a portion of one set of reinforcement or possibly to cross one set over from the inner to the outer face, but this generally cannot be insured and the full reinforcement should be put in even if only as an added factor of safety and for the sake of standardization. Another reason why the arch cannot be designed too closely is that any particular section, if multiplicity of sections is to be avoided, must be designed for variations of loading over a considerable range.

In the St. Louis work, where a considerable length of one size sewer and fairly constant soil conditions occur, it has been the practice to design a section for each 5 feet in depth of loading and to detail these sections for soft ground foundation, for hard bottom and for deep rock cut. A designer cannot follow too closely the calculated thickness of the arch, as some consideration must be given to the shape of the outside as well as the inside of the sewer. For example, if the sewer is to be built in a trench with vertical sides, it would be found much simpler to make the outside of the sewer vertical to some point above the spring point of the arch rather than to carry a small batter all the way down to the bottom of the sewer. This is because of the fact that it would cost less to fill in the small wedge-shaped space with concrete than to attempt to place and remove outside forms in the limited space available.

There seems to be no uniformity in practice as to the longitudinal reinforcement. A certain amount of steel is usually required in this direction to properly tie in the transverse bars and ½ or ¾-inch bars are often used on about 2-foot sections in both faces. If the sewer is to be constructed in hot weather and particularly in shallow cut, it might be advisable to increase the amount of longitudinal steel in order to distribute shrinkage cracks, but under other conditions this seems hardly necessary as the range of temperatures in the completed sewer is very small, probably varying from about 40 degrees F. in winter to 70 degrees F. in summer, unless steam or hot wastes are permitted to enter.

RELATION OF SPECIFIC GRAVITY TO DEGREES BAUME.

The use of the Baumé scale is a frequent source of annoyance as well as convenience to those engaged in industries in which it is used, more especially in its connection with petroleum products for use in roadwark. The relation between the two scales has been aptly explained by H. W. Bell in "Western Engineering," who says that a natural and common mistake due to the use of Baumé scale is in the mixing of different gravities of oil to obtain a product of certain gravity on the assumption that the Baumé scale is a direct measure of specific gravity. To illustrate: We have 10,000 bbl. of 16° Baumé oil and wish to know the amount of 25° Baumé oil necessary to add to bring the product up to 20° Baumé. The method of solving by proportion, without converting Baumé to specific gravity easily suggests itself, and the result would be as follows: $10{,}000\,(16) + 25A = 20\,(A + 10{,}000)$, and $A = 8{,}000$, the apparent amount to be added. But Baumé gravity is not a direct measure of specific gravity, and specific gravity $= \frac{140}{130 + \text{Baumé gravity}}$. The general form of equation would be $A_s G_s + A_a G_a = G_x (A_s + A_a)$, where A_s is amount of oil at the start; A_a is amount to be added; G_s is specific gravity of A_s; G_a is specific gravity of A_a; and G_x is specific gravity of mixture. Further, let B_s, B_a and B_x be the Baumé gravities of the oil to start, oil added, and the mixture, respectively; and putting in terms of Baumé,

$$\frac{140\,A_s}{130 + B_s} + \frac{140\,A_a}{130 + B_a} = \frac{140\,(A_s + A_a)}{130 + B_x}$$

$$\text{Solving, } A_a = \frac{A_s (B_x - B_s)(130 + B_a)}{(B_a - B_x)(130 + B_s)}$$

Using this formula and solving the given problem, the amount to be added is 8,493 instead of 8,000 bbl. If only 8,000 were added the theoretical gravity would be 19.86°, and it might easily result in refusal of purchaser to accept the shipment as 20° oil.

In the consideration of the effect of water content upon gravities, we know that they are lowered unless the gravity of the pure oil is 10° or less. To show the effect of water on specific gravity of oil mixture we can write the equation $G_o\,(100 - P) + P = 100\,G_m$ and $G_o = \frac{100\,G_m - P}{100 - P}$, where G_o is specific gravity of pure oil, G_m is specific gravity of mixture, and P is the percentage of water. Substituting Baumé degrees for specific gravity and letting B_o and B_m equal the Baumé gravities of pure oil and the mixture, respectively, the result is

$$\frac{140}{130 + B_o} = \frac{\frac{14{,}000}{130 + B_m} - P}{100 - P}$$

$$\text{Solving, } B_o = \frac{14{,}000\,B_m - 10\,P\,(130 + B_m)}{14{,}000 - P\,(130 + B_m)}$$

MORE ABOUT THE INFILTRATION GALLERY.

THERE has been considerable comment in the technical press recently on the subject of water supply by infiltration galleries. In this connection we are pleased to reprint some observations on this subject made by Alexander Potter, of New York, taken from a discussion printed in the Journal of the New England Waterworks Association for December, 1915. In the course of this discussion Mr. Potter states that the procuring of water supplies by means of infiltration galleries is not common. Even where the use of infiltration galleries promises to yield good results, engineers often hesitate to make use of them because of the many failures recorded, the causes for which either are not understood, or when understood have not been brought to the attention of the engineering profession.

The proper design of an infiltration gallery should not be at all difficult, for the process which takes place in an infiltration gallery is duplicated in nature by the diffused seepage of the underground waters into surface streams. The fundamental laws governing the ground-water flow of surface streams are fairly well understood, and apply with slight modifications to infiltration galleries. They may be stated as follows:—

1. The ground-water stream flow is fixed and limited to the surplus underground waters accumulating and stored in the valley.

2. The rate of seepage varies with the transverse hydraulic slope of the ground-water table and the porosity of the material through which the ground water flows.

3. When the hydraulic slope is not steep enough to discharge the surplus ground waters as fast as they collect in the valley, the ground-water table rises until equilibrium is established, and vice versa if opposite conditions exist.

4. Except as affected by the seasonal changes of the rising and lowering of the ground-water level, the ground-water stream flow is constant.

There is no reason why the seepage of ground water into an infiltration gallery under proper conditions should not be equally as dependable as the identical natural process of ground-water seepage into surface streams.

An infiltration gallery may derive its supply of water from two distinct sources: A supply derived by intercepting the surface underground waters which were under natural conditions joining the surface waters by diffused seepage, and a supply derived by infiltration from bodies of surface waters adjacent to the infiltration gallery. A carefully made scientific investigation will in nearly every case reveal within quite narrow limits the quantity of water available for an infiltration gallery from the two sources above mentioned, and as long as the draft does not exceed the available supply there is no reason why the yield of a properly designed infiltration gallery should gradually decrease with time, as is only too often the case. The recorded failures of infiltration galleries can, in the writer's opinion, be largely attributed to the erroneous assumption that a pipe laid below water level with open joints or perforations and surrounded by a porous material will continue to deliver the volume of flow developed when first constructed, ignoring entirely the fundamental law of supply and demand.

This is not true with infiltration galleries constructed on the floor of an impervious strata intercepting the transverse ground-water flow in a pervious strata of coarse sand immediately above. Under such conditions infiltration galleries have been very successful.

Under conditions other than that just stated, and where the supply appears to be adequate, there is often noted a gradual breaking down of the infiltration gallery, apparently due to the silting up of the filter media immediately surrounding the gallery. Under the natural conditions of ground-water seepage into surface streams no such silting appears to take place, and when such silting up occurs in connection with an infiltration gallery it can only be due to the peculiar ground-water conditions set up by construction of the gallery. Mr. Potter believes that the silting phenomena are primarily due to the high velocities of the ground water through the filter media immediately adjacent to the gallery, velocities so great that the finer particles of soil are transported to the gallery, gradually clogging the interstices in the filtering media and the gallery proper. This phenomenon of clogging is aggravated by the lowering of the ground-water level in the vicinity of the filter gallery below the top of the gallery. For a definite yield, as the wetted perimeter of the gallery decreases, the entrance velocity increases in inverse proportion. To attempt, therefore, to force an infiltration gallery to the extent of lowering the ground-water table below the top of the gallery, will tend to increase the danger from clogging and materially shorten the life of the infiltration gallery, especially when constructed in the finer sands.

With tubular wells, the question of high entrance velocity in the filtering media surrounding the well screen is not of equal importance; wells are comparatively short-lived, and when clogging does occur it can be remedied by back-flushing or other known methods. No such remedies are available for clogged infiltration galleries. When properly designed so that the yield of the gallery does not exceed the supply available from the surplus underground waters and the supply derived by infiltration from a nearby body of surface water, and the entrance velocities are sufficiently low so as not to transport the finest soil particle, the useful life of the infiltration gallery should be practically unlimited.

The yield from an infiltration gallery constructed in the finer sands should be automatically controlled so that it cannot exceed a certain predetermined amount, in order to prevent the lowering of the ground-water plane below the top of the gallery, so as to keep the entrance velocities within safe limits. This condition can best be secured by restricting the flow from the gallery to an amount which will keep the gallery constantly full of water for its entire length.

In many cases the requirements as outlined herein will for a given yield call for the construction of much longer lines of infiltration galleries, constructed in finer sands than has been the practice in the past, so that in many instances other methods of supply will be found to be more economical. Throughout the country, however, deposits of gravel and sand exist in the valleys of rivers and along lakes and seacoasts, in which infiltration galleries can be economically constructed to yield adequate supplies either from the surplus underground waters or from the water derived by infiltration from adjacent natural and artificial bodies of water, or from both sources.

In tropical countries, where there exists so strong a prejudice against the use of stored surface water for a public water supply, due to the deterioration resulting from the luxuriant vegetable growth abounding in such waters, the use of an infiltration gallery is often advisable. The natural purification which takes place in the water while passing from the surface reservoir to the infiltration gallery has been found to be effective.

CREOSOTE WOOD BLOCK PAVEMENTS.*

By Andrew F. Macallum, B.A.Sc., C.E.

FOR a number of years untreated wood block pavements were laid in this country and the United States, and after repeated failures attention was directed to the use of preservatives. The first experiments made simply placed thoroughly dried blocks in a bath of creosote heated to a temperature of about 210° F. until about three pounds per cubic foot of creosote had been absorbed.

While these pavements were fairly successful, it was soon realized that the best results could not be secured by dipping the blocks, and the blocks were then treated with creosote under pressure until they absorbed from ten to twelve pounds of oil per cubic foot. Such a pavement laid in Indianapolis in 1898 gave such good results that city engineers began to appreciate the possibilities of treated wooden blocks and better results were obtained.

On Tremont Street, in Boston, a wood block pavement treated with creo-resinate process composed of one-half creosote oil and one-half resin, was laid in 1898. The writer saw this pavement about a year ago and it was still in good condition after sixteen years of heavy traffic.

A small piece of similarly treated wood block was laid on the west side of Yonge Street, Toronto, at Front Street, opposite the head office of the Bank of Montreal in 1896, and was still in good condition when taken up for a new pavement about two years ago. The writer also examined such pavements in New York on Church and Warren Streets after they had been in use for nine years under the heaviest kind of traffic and they were still in good condition. In the city of Hamilton probably more treated wood block pavements have been laid than in any other city in Canada and the first pavements laid in 1909 are as good as when laid, and although subjected to the heaviest traffic in that manufacturing city have not, to date, cost a cent for maintenance.

These examples which I have mentioned are but a few of the numerous examples showing permanence and suitability of this form of pavement for streets carrying heavy traffic.

I may also say that it has also been laid on residential streets where the residents assume its greater cost to asphalt for the added comfort through its quietness under traffic.

The wood principally used has been long-leaf (yellow) southern pine, which, from experience, has been found to give excellent results. Most specifications now, however, admit Norway pine and tamarac as a result of experimental pavements laid in Minneapolis, which showed the suitability of these woods. No doubt other species of wood make satisfactory pavements, but on account of the incomplete knowledge of their value as paving blocks, city engineers, as a rule, prefer a wood that has proved satisfactory.

The blocks are from three to four inches wide and vary in depth from 3 to 4½ inches, with a length of from 5 to 10 inches. The depth of blocks should not vary more than 1/16 of an inch for a given size. As for all timber specifications, the blocks should be sound, free from large or loose knots, shakes, worm holes and other similar defects.

The annual rings are usually specified as to average not less than six to the inch and the blocks to average 80% of heart wood or one block not to have less than 50% heart wood.

The preservative used is usually a pure coal tar product free from petroleum oil or its products having a specific gravity of 1.10. Water gas tars have not proven satisfactory and should not be used.

The writer has been corresponding with a number of city engineers with a view of obtaining opinions as to the most satisfactory amount of treatment required per cubic foot of block according to the experience of each city, and in replies from twenty cities in the United States, has ascertained that six of these cities use 16 pounds, two of them 18 pounds, and twelve of them 20 pounds, depending to some extent on local conditions.

The percentage of treatment will vary with the block as the denser and heavier the block the smaller is the quality of oil which it absorbs. The sapwood will absorb a large percentage of the oil, but if the block has not had the moisture first removed from the sapwood the oil will not be able to penetrate. Thus it is invariably found that a block which fails does so in the sapwood and the cause is insufficient amount of oil or poor penetration of the sapwood.

Laying the Pavement.—The base for wood block pavements should be of concrete from five to six inches deep, having the crown parallel to the finished crown on the blocks. An uneven or irregular base is detrimental to any pavement as it is liable to cause a depression in the surface to hold water which the repeated impacts of wagon wheels is certain to increase, giving an uneven surface. Upon this concrete base is placed either a sand or mortar cushion, usually one inch deep with its surface struck by templates to a surface parallel to the contour of the finished pavement. Where sand is used the sand is such that it will all pass through a ¼-inch screen, besides being clean. If a mortar cushion be used, some engineers use a proportion of one of cement to three of clean sand, to which sufficient water is added to insure the proper setting of the cement, while other engineers obtain good results by mixing and placing the cement and sand dry. This cushion is simply a means of securing a uniform surface for the blocks to rest upon and distribute the load. Alongside or between street car tracks, however, or on grades, sand cushions are apt to become uneven or flow, caused by the vibration of the rails or by water getting in alongside the rails, so that under these circumstances a concrete cushion should be used. Away from the car tracks the question of whether a sand or mortar cushion should be used is a matter of opinion. Sand gives a better cushioning effect and the blocks do not have to be rolled so soon after laying as when a mortar cushion is used, but the present tendency seems to favor a mortar cushion.

European practice does away with this cushion altogether, but the concrete base is finished off as smooth as a concrete sidewalk and to the exact contour of the surface of the pavement. This extra care and workmanship obtains results that are excellent in as much as the finished surface of the blocks have no depressions and consequently the wheels cause no impacts.

In most cities it is not possible to lay the blocks shortly after coming out of the treating plant and the hot sun and wind during shipment and before laying is apt to check the blocks and cause oil to exude. The blocks should be piled closely when delivered on the street and sprinkled or dipped in water before laying.

Generally the blocks are laid at right angles with the curbs with an expansion joint at each curb of from three-quarters to an inch and a half, according to the width of the pavement. Alongside the curbs three rows of block are laid parallel to the curbs with the expansion joint next to the curb. Placing a longitudinal row of blocks with an

*A paper read at the 3rd Canadian and International Good Roads Congress.

expansion joint on each side is sometimes done, but is not good practice, as the single row of blocks between the joints will almost certainly rise up about the level of the adjoining pavement as the joints close up. Cross expansion joints have been used also by the writer when the treated block used had been piled on a street for several months, but for fresh blocks properly treated they are not necessary on streets of heavy traffic. On streets of light traffic, however, there should be cross expansion joints placed from 30 to 50 feet apart and having a width of about three-quarters of an inch. It is hardly necessary to say that the blocks should be laid with the grain vertical and having the joints in adjacent rows, broken by a lap of about two inches. The blocks should be laid neither too loose nor too tight, so that a block can be raised without disturbing the surrounding blocks, or one-eighth of an inch apart.

After the pavement is laid it should be rolled thoroughly with a roller varying from three to five tons until a perfect surface has been secured with no depressions and the blocks firmly in place. There should be no difficulty in this, as the usual specification for blocks allows of a variation of but one-sixteenth of an inch in depth so that if the foundation and cushion have been properly laid there is usually very little trouble about depth of the blocks.

Alongside street railway tracks and about manholes, special care should be taken in laying the blocks. It is usual in such cases to thicken the cushion so that the blocks shall be about one-quarter of an inch above the wearing surface of the rail or cover, and in a very short time the traffic will rub these blocks down to the level of the rail. Alongside rails to prevent water flowing down and under the blocks two methods are used: one is to place specially cut creosoted plank under the rail head to give a vertical surface against which the blocks are paved and the second and usual method is to plaster the web with a rich mixture of sand and cement to the width of the rail head and the blocks are then laid against this. As with other pavements, it has been found that the girder lip rail is more satisfactory than the ordinary T-rail, unfortunately in use in most towns, for the permanence of the block on the inside or gauge side of the rail. Incidentally, it may be said that no pavement will be satisfactory alongside a street railway track if the rails lack sufficient weight, stiffness and foundation to prevent movement, especially at the joints.

There is diversity of opinion among engineers as to the best joint filler to be used. The American Society of Municipal Improvements, of which the writer has the honor of being president, recommend a suitable bituminous filler when the blocks are laid upon a sand cushion and a sand filler when laid on a mortar cushion. It is claimed for the bituminous filler, which fills the joints between the blocks two-thirds their depth (the remaining depth filled with sand) that it makes an absolutely waterproof pavement, and that it eliminates all expansion difficulties as such block is surrounded with an individual expansion joint. Unless the filler is a suitable asphaltic cement with a high melting point and low penetration, there is apt to be a sticky surplus left on the surface. This filler will cost about 15 cents per square yard more than a sand filler.

A cement grout filler has been used, but unless the traffic can be kept off the pavement for at least 10 days it is little better than a sand filler.

The sand filler is generally used on streets of heavy traffic; the sand being coarse and sharp-grained, and preferably heated before placing. The writer has used with excellent results a bituminous filler between and one foot outside of street railway tracks and a sand filler to the curb where three rows are again treated with a bituminous filler. From results obtained he does not consider the extra expense in using bituminous filler justified for such streets unless the traffic be very light. On bridge floors it is better practice to use a bituminous filler with the blocks. After the pavement is rolled, sand to the depth of about a quarter of an inch is spread over the surface and the street is thrown open to traffic.

This method of construction is satisfactory up to a 3 per cent. grade, beyond which the blocks are laid in a different manner. The crown should be as light as possible, being just sufficient to shed the water freely, which applies also to the pavements between street railway tracks.

When the grade of a proposed pavement exceeds 3 per cent. the question of a suitable pavement, and the method to be adopted in laying it, to meet the requirements of the traffic, becomes of interest. With the variability of conditions to be met with due to our climatic changes the limits of most paving material is soon reached, so far as the inclination of grade is concerned, unless specially manufactured.

The writer inquired from twenty-four cities to ascertain the maximum grades upon which creosoted wood block had been laid and found that one city had laid this pavement on a 7 per cent. grade, one on 6 per cent., three on 5 per cent., and five on 3 per cent. grades. The 5 to 7 per cent. pavements were laid under two methods, described below.

The first method used was probably originated in this city and was used on upper James Street with the block pavement laid there in 1909 on a 5½ per cent. grade. Each block had a piece one-half inch in width and one-half inch in depth, cut off one face so that when the blocks were laid at right angles to the centre line of the street there was a space of a half inch between each row of blocks, giving a good foothold for the horse-drawn traffic. These blocks were pitch filled and the cross grade of the street was sufficient to drain out any water.

The same method was adopted on King Street West in this city, during the same year, and I may say that both of these pavements have been very successful in meeting the conditions of heavy traffic on two of our main streets without a cent being spent for repairs or renewals since being laid.

The special cutting of the blocks in the manner described added considerably to the cost of the pavement, and to obviate this the ordinary rectangular block was used with creosoted laths ⅜ in. x 2 ins. laid between each cross row of blocks. This was pitch filled, as in the first method, and has been just as successful, being to-day in first-class condition, although subjected to fairly heavy traffic for four years.

On Ravenscliffe Avenue, a purely residential street, having a 6 per cent. grade, blocks spaced in this manner were laid. The reason for putting such a pavement on a street like this, having very little traffic, was that the residents insisted on a creosoted wooden block pavement because of its quietness as compared with other pavements suitable for such a grade, and it has fulfilled expectations.

One of the criticisms made of treated wood block pavements is that it is slippery, but in the writer's experience he has found that there is very little difference between these blocks and sheet asphalt pavements. When covered with a light frost or snow, or when the weather is foggy and damp the pavement may become objectionably slippery.

In traffic observations made at Philadelphia, Newark and other cities the evidence shown by the engineers at

these places indicated that where treated wooden block and granite blocks were on parallel streets 70 per cent. of the teaming went on the wooden block.

On Stuart Street in the city of Hamilton, the writer laid treated wooden blocks between the street car rails and granite block between the outside rails and curbs, the pavement being on a 5 per cent. grade. Although most of the traffic was of heavy truck teaming nature it was found that fully 80 per cent. of the traffic, except on wet days, was on the wooden block.

The first cost of wood block pavement is undoubtedly higher than that of most of the other paving materials, averaging in the city of Hamilton from $2.85 to $3 per square yard, exclusive of grading. When its cheapness of maintenance, ease of cleaning, low tractive resistance and durability are taken into consideration this pavement with its relatively high first cost will compare favorably and prove ultimately cheaper than one lower in first cost.

EARTH DAMS.

In *The Canadian Engineer* for January 27th the design and construction of masonry dams were discussed in an article by Messrs. A. P. Davis and D. C. Henny, abstracted from a paper on dams read at the International Engineering Congress in San Francisco. The following discussion of earth dams is from the same paper.

The design of earth dams is not subject to mathematical analysis. It must of necessity be based on the application of general experience. This type of dam, being the result of slow evolution, the experience of recent years has been able to add relatively little to known facts, and any considerable departure from previous practice is mainly in the methods of handling. The magnitude of structures of this class has, however, greatly increased. General requirements are somewhat better understood, while new methods of handling materials have had their effect upon design.

The original conception of an earth dam probably was a mass of material compacted so as to be water-tight throughout, connecting with a tight substratum and disposed to slopes somewhat flatter than the angle of repose. Extensive cores of puddle or heavy walls of masonry were used in the centre of the structure when doubt existed as to the water-tightness of the general mass.

The use of a clay puddle core, with a dam of material more or less open to percolation, has become less frequent than heretofore in ordinary dam construction, while the heavy masonry core, common in early eastern dams, has been greatly reduced in dimensions and has been made less rigid as a diaphragm through the use of reinforced concrete. Where a core is used, it is frequently carried up to only partial height so as to break the path of the water trying to percolate under the base of the dam.

The character of puddle now deemed safest by most engineers is not pure clay, but a mixture of gravel, sand and clay well blended and compacted by a heavy roller, with a small admixture of water. This material is less liable to cracking and slipping than pure clay and absorbs less water. There is, moreover, a greater tendency, where only a portion of the dam is tight, to place this portion as close as practicable to the water face, thereby increasing the backing which supports it; also to employ coarser material for the downstream portion of the dam, for greater stability and better drainage. Hundreds of earth dams have been built within the last two decades under a wide variety of conditions. As failures of earth dams have been generally due to overtopping, to piping under the foundation or along outlet conduits, or to sloughing, special attention has been paid to safeguards against such accidents.

In regard to overtopping, protective measures have consisted of close study of possible flood flow and provision of ample spillway capacity and freeboard. Piping under the foundation, which may occur where connection cannot be made with a tight substratum, is guarded against by lengthening the path of the water through slope flattening, by deep puddle-filled cut-off trenches, sheet piling. Grouting was used in connection with a deep cut-off wall in the case of the Lahontan dam, which is built mostly on mudstone in which many fissures occur. Piping along outlet conduits is prevented by construction on unyielding foundation and by frequent and large cut-off collars. Sloughing is prevented by the use of masses of open drain material in the downstream body of the dam, by drainage pipes, or partially by above methods as well as by extreme care in construction, through limiting water contents and hard rolling with traction engines. In the latter case, it is believed that the clay was rolled into such a compact and rubbery mass as to prevent the penetration of water other than by capillary action.

More scientific processes have been employed lately in the determination of rates of percolation which would take place through materials at hand for dam construction, made necessary, especially in the west, because of general sandiness of surface material. It was found, as in the case of the Cold Springs dam and, subsequently, in the case of the Lahontan dam, that mixtures of available materials could be used which gave rates of percolation about one-ninth that of the tightest material at hand, if used by itself. Thus, it has been economically possible to construct practically tight dams with sandy material. In such cases, mixtures have been graduated so as to increase in perviousness away from the water face, to secure perfect drainage.

In one important case conservative methods of earth-dam construction have been deviated from by omitting sprinkling and rolling and by loose dumping the clayey materials from trestles. The results have been unsatisfactory, as might have been surmised, in causing over 10% of settlement in the height of the structure with water about two-thirds of its intended height, accompanied by bulging, cracking and some leakage, causing fear as to the safety of the structure and an order from the authorities to reduce the height of water in the reservoir.

Slopes of earth dams are generally 3 to 1 on the water face, and 2 to 1 on the dry face, although steeper slopes have been successfully used, as in the case of the Belle Fourche dam, where they are 5 to 1 for a short distance, then 2 to 1 and 1½ to 1 on the water face and 2 to 1, with two 8-foot berms, on the dry face.

In the compacting of the earthy portions of dams, there has been a tendency to thin layers (6-in.) and to the use of heavy rollers 10 to 30 tons, or preferably traction engines, as giving great concentration of loads and avoiding continuous jointing planes.

The most radical departure from former methods of dam construction has been the occasional adoption of the hydraulic method of conveyance and deposition, on works of the greatest magnitude, such as the Gatun and Necaxa dams, and the Calaveras dam in California, now under construction. The use of this process, and the consequent results, constitute perhaps the most interesting chapter in the recent history of dam construction. The interest attaches to this process, not only as a measure of economy

in construction, but still more to the results obtainable from the skilful employment of the sorting power of water in separating heterogeneous masses of material into their constituent parts, and placing each where it will do the most good.

The largest and one of the most interesting earthen dams ever built, has recently been completed at Gatun on the Isthmus of Panama. It impounds in Gatun Lake the waters of the Chagres River, and thereby forms the summit level of the Panama Canal, extending from Gatun, about seven miles from the northern terminus of the canal, through the Culebra Cut to Pedro Miguel, a distance along the sailing route of the canal of 32 miles. The area of Gatun Lake at normal high water is about 165 square miles, and its depth about 75 feet. It thus follows that this dam is one of the most important structures on this great work. The Gatun dam, as finally built, contains about 21,000,000 cubic yards of earth and rock, most of it being clay pumped into place by hydraulic dredges. The bottom of the valley is about 10 feet above mean sea level and a wide cut-off trench carries the base of the dam slightly below sea level. Its top is about 105 feet elevation, or 20 feet above normal high water in Gatun Lake. Its maximum width of base parallel to the valley is over 2,000 feet, the upstream slopes averaging about 7 to 1, and the downstream slopes varying between 8 to 1 and 16 to 1, with an average of about 12 to 1. These conservative lines were adopted for a number of reasons, among which the following were the most important:

1. The extremely soft, yielding foundation made it imperative to avoid any large increase of load on any portion over that on the ground adjacent. Hence, steep slopes had to be avoided, especially on the downstream face.

2. The hydraulic fill being presumably less pervious than portions of the natural foundation it was desired as a blanket to the latter, so as to enforce a long line of travel for percolating waters, and to fortify against boils and blow-outs below the dam.

3. The extreme importance of the structure to the integrity of the canal emphasized the importance of using very large factors of safety against destruction by both natural and artificial forces.

The Consulting Board of 1905, which outlined the lock canal project involving the Gatun dam, gave greatest weight to the second consideration above named. That Board proposed to carry the dam to an elevation of 135 feet above sea level, thus giving a freeboard of 50 feet above normal high water.

Subsequent experience convinced the Consulting Board of 1909, that instability of foundation, and of the material of which the dam was to be built was the greatest difficulty to be overcome. Hence, the large freeboard proposed would prove a menace by unnecessarily overloading the foundation at the axis, and it recommended a reduction of height to 115 feet above sea level, thus reducing the freeboard from 50 feet to 30 feet. Further experience led to an additional reduction of 10 feet in height, which is doubtless an improvement in stability, besides saving cost.

Even with such flat slopes at 7 or 8 to 1, difficulty was encountered in holding the hydraulic fill in place till it could be drained and consolidated. In expediting this process, more than half the earth pumped into the dam was carried away with the drainage water. It is the opinion of those best able to judge, that with the conditions presented and materials available, it would not have been practicable to build the dam by that process on much steeper slopes than those adopted for the upper half of the dam.

The hydraulic method of depositing clay implies that it goes into place in a supersaturated condition, often containing 50% of water. The difficulty of holding supersaturated clay in the interior of a high fill was vividly illustrated in the Necaxa dam, which was constructed in Mexico for the Mexican Light and Power Co. Its construction by the hydraulic method was a bold undertaking, the supply canal alone costing $250,000, and the transportation, by running water, of large rock being a prominent feature of the plan.

The upstream slope was 3 to 1, and the downstream slope 2 to 1, both slopes being formed of fragmentary rock, while the interior mass was of clay, all deposited by water. The volume was 2,130,000 cubic yards, forming by far the highest earth dam ever built, its height being 190 feet.

Owing to the slow drainage of the clay body of the dam, it retained a semi-liquid consistency, and when the dam was nearly completed, the lateral pressure of the clay forced the water face into the reservoir, and about 750,000 cubic yards of material followed it. This impressive accident, as well as the experience at Gatun, where bulging up of slopes was experienced, illustrates the instability of undrained clay, and the limitations of the hydraulic method of handling such materials.

For handling sand, gravel, small rock, and mixtures of these materials with clay or silt, the hydraulic method has demonstrated its economy under favorable conditions, and it produces good results when its sorting powers are skilfully employed upon such materials, by depositing the finer particles in an impervious core, and the coarser, on the exterior slopes where they furnish efficient drainage on the lower side, serve as efficient protection against wave action on the upper side and lend stability against sloughing to both.

The Calaveras dam in California, which will be the highest earth dam on record (250 feet) is now being built by the hydraulic method.

The hydraulic process requires great skill, and attempts are now being made to utilize it in the construction of banks in which the materials are to occur in well-mixed condition, the clay to be retained in the interstices of the mixed sand and gravel. To this end, shear boards are used to guide the mixed waterborne material in a way that will cause it to drop its load without segregation. To what extent this method can be made to produce the desired results remains to be seen.

In some cases, as in the Bumping Lake dam in Washington (without core wall) and the Arrowhead dam in California (with core wall), the hydraulic process has been used in washing material from the slopes into a central pool, the material having first been hauled and dumped on the slopes by mechanical methods. Such procedure has advantages where it is feared that the material as dumped cannot be rolled into a tight mass without expensive selection and waste, and where water under gravity pressure is available for cheap assorting and conveying to place.

CHANGE OF ADDRESS.

The United States Cast Iron Pipe and Foundry Company announces the removal of its Southern Sales and Traffic Offices from Chattanooga, Tennessee, to 1002 American Trust and Savings Bank Building, Birmingham, Alabama. This change becomes effective April 1, 1916.

MINERAL PRODUCTION

In response to the call for increased production, the mine owners of Canada last year made the second best record of mineral production in the history of the country. The total value was $138,513,000, compared with $128,863,000 in the previous year, (during which business was almost at a standstill for five months), and $145,634,000 in 1913. This record was made last year, despite decreases in the output of construction material, due in turn to the lack of demand. The war created a demand for nearly all metals and this fact helped materially to swell mineral production. The obtention of by-products of coal also contributed. As a result of the war activity, too, we have become a producer of zinc ore to a small extent and we will have a nickel refinery on our Atlantic seaboard in the comparatively near future. The fact that under war conditions it was desirable that our metals should become available for commercial or national use, entirely within the country and that we should be less dependent, even upon a friendly neutral, for their recovery in smelters and refineries has stimulated the development of our smelting and refining operations. Amongst non-metallic minerals the recovery of benzol and toluol in by-product coke oven operations was a direct result of the war, as was also the activity in the mining and shipment of magnesite and of chrome ores.

Ontario contributed $61,800,000 to the total mineral production last year, more than twice British Columbia's output of $28,932,000 and more than three times Nova Scotia's production of $18,126,000. Ontario leads in gold and silver production and has a monopoly of Canadian nickel production. The coal fields are the chief contributing factor to Nova Scotia's output and the asbestos deposits in the eastern townships help to place Quebec in fourth place among the provinces with a mineral production of $12,159,000 last year.

The total value of metals produced in 1915 was $77,046,000, an increase of $18,000,000 over the previous year. The value of non-metallic minerals was $42,755,000, while structural materials and trade products accounted for $18,712,000. Among the principal non-metallic minerals were coal, natural gas, asbestos, gypsum, pyrites, salt and petroleum. Natural gas production shows a decrease, indicating that the sources which have been heavily tapped in past years, are beginning to give out. Petroleum production also shows a decrease.

While this record of mineral production last year is satisfactory, largely because of an increase compared with the previous year, our output is by no means as heavy as it should be. There is considerable scope for first-class prospecting, for the employment of further capital in the industry, and for the services of the legitimate mining engineer who has too often been forced by the "wild cat" company promoter to take a back place. Mr. John McLeish, B.A., chief of the division of mineral resources and statistics, is to be congratulated upon the dispatch with which he has gathered the material for his preliminary report on mineral production, and from which the figures quoted above are taken. This report has just been issued by the Mines Branch, Ottawa.

The Alberta legislature is authorizing the flotation of a loan of $2,000,000. The funds will be used for the civil service for covering any debt on open account, for paying off floating indebtedness, for any public works and other purposes the legislature authorizes. It will be issued at a rate not exceeding 5 per cent. Hon. C. R. Mitchell is the provincial treasurer.

COAST TO COAST

Toronto, Ont.—It is expected that the Don section of the Bloor Street Viaduct will be ready for steel by April 1.

Ottawa, Ont.—Legislation has been secured for the construction of a highway between Ottawa and Prescott. The estimated cost will be $600,000.

Fredericton, N.B.—The Fredericton Gaslight Company has submitted a series of proposals relative to the lighting of the city streets by them.

Edmonton, Alta.—According to the report of the Provincial Department of Public Works there were 343 new bridges erected last year and 177 repaired.

Hamilton, Ont.—City Engineer Macallum recommends that the route selected by the C.N.R. through the city be followed by the Hydro Radials.

Vancouver, B.C.—The D. A. Thomas interests are prepared to negotiate with the government as regards the building of a railway into the Peace River country.

Medicine Hat, Alta.—A delegation has interviewed Premier Sifton at Edmonton urging that the C.N.R. be ordered to complete their line between Medicine Hat and Hanna.

Toronto, Ont.—The city has submitted an agreement to the York Township council by which they will supply the adjoining districts with water at 20 cents per thousand gallons.

Edmonton, Alta.—The Alliance Power Company has submitted an offer to the city by which they will agree to operate the city power plant until the new hydro-electric plant is ready.

Winnipeg, Man.—An official statement given out at the Canadian Northern Railway offices here announces the opening of the line from Camrose to Alliance, Alberta, a distance of 59 miles.

Winnipeg, Man.—The Jefferson highway will enter Canada at Emerson and follow the route of the Meridian Road to Winnipeg. When completed, the road will extend from New Orleans to Winnipeg.

Vancouver, B.C.—The annual report of the Provincial Water Board shows that the storage capacity of the small lakes on Seymour and Capilano Creeks is ample for a city many times the population of Vancouver.

Calgary, Alta.—The watermasters of the irrigation district east of Calgary held their second annual convention at Strathmore. Irrigation matters were discussed and lectures were given by government engineers.

Niagara, Ont.—The construction of a canal eight miles long, which will provide a new waterfall here, will be undertaken during the coming summer. The cost will be about $12,000,000 and 600,000 h.p. will be developed.

Moose Jaw, Sask.—City Engineer Mackie has a scheme by which he proposes to bring water from the Saskatchewan River to Caron and thence through the existing pipe line to the city. No particulars are available.

Peterborough, Ont.—The Utilities Commission of the city of Peterborough is authorized to negotiate with the Otonabee Power Company for the purchase of their transmission lines in that city where they do not parallel the Hydro system.

Montreal, Que.—The Montreal and Southern Counties Railway expects to be able to run to Granby by the end of March. The new machinery will shortly be installed in the sub-station. Granby will be the furthest objective point this coming summer.

Lethbridge, Alta.—The provincial bacteriologist has concluded an investigation into the epidemic of typhoid which has been raging here. He states that raw sewage which is dumped into the Old Man River at Macleod is responsible for the epidemic.

Hamilton, Ont.—It is understood that the Dominion Government has consented to defer to Ontario in the control of franchises and charters of local electric railways, and that this policy will be followed by the Railway Committee of the Federal House in dealing with the Canadian Northern Ry. charter extensions for their Niagara lines.

Toronto, Ont.—A $700,000 programme has been outlined by the Harbor Commission in connection with next summer's work. The work in Ashbridge's Bay and at the Humber will be continued, and, in addition, the work of transforming the old harbor will be commenced. It is announced from Ottawa that a permanent head line has been established in the harbor, from Bathurst Street to Yonge Street. The plans provide for the establishing of a 17-acre industrial area at the foot of Bathurst Street, which will be served by 800 feet of dock and 20 feet of water. There will also be modern freight sheds and a factory building. In connection with the new windmill line, the railways have waived their riparian rights between Bathurst and York Streets and the companies will join the commission in an application to the government for approval of the new pierhead and bulkhead lines, and the harbor commissioners will receive the patents to the new lots lying between pierhead and bulkhead lines, Hon. Mr. Rogers and Hon. Mr. Hazen both having signed them.

Letters to the Editor

Stresses in Lattice Bars of Channel Columns.

Sir,—Those of your readers who are interested in the mechanics of materials will be interested in Mr. Pearse's solution for the stress in lattice bars of columns, published in your issue of February 24th. On the hypothesis that there is a bending stress at the centre of a loaded column, the magnitude of which stress is correctly given by the amount of the reduction made in the allowed unit stress on account of the length of the column, Mr. Pearse's method is correct. Unfortunately, on account of an error at the beginning of the deduction of the formula, the result he gets for the stresses is twice too much.

In the discussion of the question of stresses in lattice bars of columns it must not be forgotten that our knowledge of the internal stress conditions of a column under load is very vague. In columns tested to failure, up to a considerable length, there is practically no deflection in the column until the elastic limit of the material is reached, when failure occurs by a local buckling. If a latticed column were perfectly constructed, of homogeneous material, with the two parts exactly straight and of the same area, and if the load were applied absolutely concentric, there would be no bending in the column up to the point of failure. In such a column the lattice bars simply hold the two parts together and would have only very small stresses in them until at the moment the column failed. Practically, there are columns of all conditions, from the one nearly perfect to the one grossly imperfect, and the stresses in the lattice bars will be of all kinds and magnitudes. In longer columns, such as it is practical to manufacture, there will be bending in the column before failure occurs. Bending will probably start as soon as any part of the load is applied. Unfortunately, it is impossible to have any knowledge of the relation between the load, the elements of the column and the amount of the bending; such relationship being purely accidental and not the same in any two cases. For a certain definite load and a corresponding bending, there will be certain stresses in the lattice bars which can be determined with a fair degree of approximation; it being, of course, assumed that the latticing is at least sufficient to make the two parts of the column act as one column.

Nearly all text books, however, in their treatment of the theory of the column, assume that there are certain definite and determinate bending stresses in a loaded column and give formulæ for the determination of the amount of these stresses. Formulæ, such as Mr. Pearse's, may be deduced on the basis of these assumptions and the stress in a lattice bar calculated therefrom. The addition of the stress so calculated to the accidental unknown stress will give a result which will be quite safe to design to, but what will this resulting stress be?

Mr. Pearse, in his derivation of the formula, says that the total stress in channel CR is $2k\frac{A}{2}$, due to bending. This should be $k\frac{A}{2}$, since k is the unit stress due to bending and $\frac{A}{2}$ is the area of the channel. If this corrected value be used throughout Mr. Pearse's demonstration it will give the correct result, which is just one-half that given by his final formula.

The writer has deduced the following solution for the transverse shear, and suggests it as being shorter and more general than Mr. Pearse's.

The curve of a column concentrically loaded, with deflection Δ is $y = \Delta \sin \pi\frac{x}{l}$.

Let M be the bending moment from load P, at point x, and $M + dM$ the moment at $x + dx$.

$$M = Py = P\Delta \sin \pi\frac{x}{l}.$$

$$M + dM = P\Delta \sin \pi\frac{x + dx}{l}$$

Therefore, $dM = P\Delta\left(\sin \pi\frac{x + dx}{l} - \sin \pi\frac{x}{l}\right)$

$$= P\Delta\left[\sin\left(\frac{\pi x}{l} + \frac{\pi dx}{l}\right) - \sin \pi\frac{x}{l}\right]$$

$$= P\Delta\left[\sin\frac{\pi x}{l}\cos\frac{\pi dx}{l} + \cos\frac{\pi x}{l}\sin\frac{\pi dx}{l} - \sin \pi\frac{x}{l}\right]$$

and since $\frac{dx}{l}$ is very small, $\cos\frac{\pi dx}{l} = 1$, and $\sin\frac{\pi dx}{l} = \frac{\pi dx}{l}$, the first term will cancel the last and

$$dM = P\Delta \cos\frac{\pi x}{l}, \frac{\pi dx}{l}.$$

Therefore, $$\frac{dM}{dx} = P\Delta\frac{\pi}{l}\cos\frac{\pi x}{l} \quad - \quad - \quad - \quad (1)$$

If M is the bending moment at x, then $\frac{dM}{dx} = S$ is the transverse shear at x, and

$$S = P\Delta\frac{\pi}{l}\cos\frac{\pi x}{l} \quad - \quad - \quad - \quad (2)$$

Let M_0 be the bending moment at the centre, f the extreme fibre stress due to M_0, r the radius of gyration, A the area, and c the distance from the neutral axis to the extreme fibre.

Then, $P\Delta = M_c = \frac{fI}{c} = \frac{fAr^2}{c}$,

Substituting in Equation 2,

$$S = f\frac{Ar^2}{c}\frac{\pi}{l}\cdot\cos\frac{\pi x}{l} \quad . \quad - \quad - \quad (3)$$

This equation gives the transverse shear at any point x in a column.

If $x = \frac{l}{2}$, $\cos\frac{\pi x}{l} = 0$, and $S = 0$.

If $x = 0$, $\cos\frac{\pi x}{l} = 1$ and the shear at the end,

$$S_e = f\frac{Ar^2}{c}\frac{\pi}{l} \quad - \quad - \quad - \quad - \quad (4)$$

If $70\frac{l}{r}$, in the equation $\frac{P}{A} = 16{,}000 - 70\frac{l}{r}$, be substituted for f, then $S_e = 220\frac{Ar}{c}$.

If any straight line formula be used for the value of f, then the value of S_e will be independent of the length. If f be made a function of $\left(\frac{l}{r}\right)^2$, S_e will be greater for long columns than for short ones.

The writer is unable to follow the relationship claimed by Mr. Pearse between the stresses as calculated from his formula and those determined by the tests, the results of which are published in Bulletin No. 44, University of Illinois. In those tests the stresses in all lattice bars seemed to be purely a matter of chance. There were no definite stresses from bending in the columns in either the bars or the channels. In these tests the axis of the pin was parallel to the plane of the lacing, so that the columns had fixed ends in the direction of the lacing. The columns were too short to make the tests of any value in determining the effect of bending, even had they been arranged with the axis of the pins in the other direction. The opinion of the author of that bulletin is that it is impossible to establish any relationship between the stresses in lattice bars and the other elements that enter into the design and construction of columns.

A. H. HARKNESS.

Toronto, March 20th, 1916.

Stresses in Lattice Bars of Channel Columns.

Sir,—The writer has carefully reviewed the article on this subject by Mr. William Worth Pearse, C.E., city architect of Toronto, which appeared in your issue of February 24th, 1916, and begs leave to submit the following comments:—

While the column formulas here used would lead one to suppose that the stresses in columns result from a combination of direct stress and bending, it by no means follows that bending stress alone governs the stresses set up in the lattice bars of a built-up column.

An absolutely perfect column with vertical axis, would merely shorten under load effect and no bending could be produced if the material is isotropic, the load applied centrally, and the modulus uniform within the limits of loading.

However, these are all conditions which can never be realized, so that a perfect column does not exist, and hence any deflection which may occur under load effect must be regarded as the result of a combination of several accidental circumstances.

After a critical examination of practically all modern column tests it appears that columns fail when the maximum stress reaches the yield point of the material. Up to this point the behavior is very uniform with slight deflections except when a column shows some local weakness. Failure follows suddenly either by buckling of a part of the section in the case of latticed columns, or by buckling of outstanding flanges in built-up columns. At the time of local collapse, the column as a whole undergoes a large deflection while the stress drops off.

Just what portion of the ultimate stress is due to bending effect will depend entirely on accidental conditions, such as initial straightness, variations in the elasticity of different parts of the section, eccentricity of loading, distribution of metal in the cross-section, and finally, the degree of fixity at the ends. It matters not how the ultimate is produced, but whenever the sum of the direct stress and bending reaches the yield point, the column fails.

If we may assume our column formulas as representative of average practical conditions based on more or less standard column designs, then no doubt the bending effect may be evaluated from whatever formula we choose to employ.

According to Navier's formula, the maximum unit stress on the extreme fibre of any piece, subjected to direct stress and bending, is given by the formula

$$S_c = \frac{P}{A} + \frac{Mn}{I}\text{ or }\frac{P}{A} = S_0 - \frac{Mn}{Ar^2}, \quad - \quad (1)$$

wherein $\frac{P}{A}$ = average working stress per square inch, and $S_0 = 16{,}000$ lbs. per square inch, represents the maximum allowable unit stress. M = bending moment; n = distance from neutral axis to extreme fibre; A = area and r = radius of gyration.

In Equation (1) the term $\frac{Mn}{Ar^2}$ represents the unit stress due to bending alone, hence for a uniformly loaded beam on two supports this moment $M = R\frac{l}{4}$ where R = the end reaction or shear.

$$\text{Therefore, } \frac{Mn}{Ar^2} = \frac{nlR}{4Ar^2} \quad . \quad - \quad - \quad (2)$$

Assuming the column formula in most general use, which is

$$\frac{P}{A} = 16{,}000 - 70\frac{l}{r} \quad . \quad - \quad - \quad - \quad (3)$$

the negative term represents the unit stress due to bending precisely as in Navier's formula, hence the bending stresses from Equations (2) and (3) may be equated. Thus $\frac{Mn}{Ar^2} = \frac{nlR}{4Ar^2} = 70\frac{l}{r}$, which solved for R gives Mr. Pearse's Formula (d), for the end transverse shear in the column, as

$$R = \frac{280Ar}{n} \quad - \quad - \quad - \quad - \quad (4)$$

For two sides of the column and single lacing, there will be two lacing bars to carry this shear, and calling θ

the angle which the bar makes with the transverse shear (usually 30°), then the stress in a single lattice bar

$$s = \frac{R}{2} \sec \theta \quad - \quad - \quad - \quad - \quad (5)$$

If the Rankine-Gordon formula is adopted in preference to Equation (3), then the end shear may be deduced in precisely similar manner by writing the formula so as to separate the bending stress from the direct stress, as follows:

$$\frac{P}{A} = \frac{16,000}{1 + \frac{l^2}{12,000\, r^2}} = 16,000 - \left[16,000 - \frac{16,000}{1 + \frac{l^2}{12,000\, r^2}}\right] (6)$$

The last term in Equation (6) now represents the unit stress due to bending alone, and as above,

$$\frac{M n}{A r^2} = \frac{n\, l\, R}{4 A r^2} = 16,000 - \frac{16,000}{1 + \frac{l^2}{12,000\, r^2}},$$

which solved for R and reduced, gives

$$R = \frac{5.33\, A\, l}{n\left(1 + \frac{l^2}{12,000\, r^2}\right)} \quad - \quad - \quad - \quad (7)$$

The formula for designing lattice bars, using a factor of safety of 3.25 should have been written as follows:

$$\frac{P}{a} = 6,600 - 13.8 \frac{l}{r} \quad - \quad - \quad - \quad (8)$$

instead of Mr. Pearse's Equation (18).

Taking the column used by Mr. Pearse, upper right-hand of page 276, where $l = 144''$, $A = 8.92$ sq. in. = two 10″ channels at 15 lbs., $r = 3.81''$, $n = 5.72''$ and $\frac{l}{r} = 38$, then by Equation (4),

$$R = \frac{280\, A\, r}{n} = 1,663 \text{ lbs. and } s = \frac{R}{2} \sec \theta = 960 \text{ lbs.}$$

Also, by using Equation (7),

$$R = \frac{5.33\, A\, l}{n\left(1 + \frac{l^2}{12,000\, r^2}\right)} = 1,068 \text{ lbs. and } s = \frac{2}{R} \sec \theta = 617 \text{ lbs.,}$$

and for the same column, 24 ft. long, $R = 1,616$ lbs. by Equation (7).

According to Equation (8), $\frac{p}{a} = 6,600 - 13.4 \frac{l}{r}$ for lattice bars, and a bar 2½″ × 5/16″ — 10.6″ long with $\frac{l}{r} = 118$ would be good for a working load of 3,480 lbs. and safe for a load three times this amount.

While above results are ridiculously small, and would not govern lattice bar design, this is all the stress that the bending effect of the column would produce. We must, therefore, look to other more severe conditions to find an answer to this problem.

The reasons for the greater bar stresses obtained from Equation (16) given by Mr. Pearse are due to the erroneous assumptions in his stress distribution, as shown in his Fig. 4, and also to the introduction of the value for Δ from his Equation (7) for which there is no justification. The apparent agreement between the lattice stresses as found from his Equation (16) and those deduced from experiments given in Bulletin No. 44, University of Illinois, is not at all convincing to the writer. These experiments do not show maximum lattice stresses at the ends of columns nor can the ratio 0.0251, for transverse shear to compression load, be regarded as governing except for the peculiar column tested. Hence, it is dangerous to generalize on such a meagre assortment of facts.

Among the conclusions given in Bulletin 44, p. 63, items 8 and 15 are here quoted to show the opinions of the experimenters themselves, which should not be overlooked in connection with the subject under discussion. They are:

8. "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations or on data now available."

15. "No relation has been found between the stresses actually observed and the stresses computed by column formulas. The stresses do not increase toward the middle of the length of the column, as may be expected from the Rankine form of analysis, but are quite irregular in their location and distribution."

Other similar remarks are given in various parts of the bulletin.

Since a latticed column is really a framed structure with rather peculiar loading, the stresses in the diagonal bracing or lacing bars will depend entirely on the behavior of the flange members. These flanges being subjected to compression from end to end, the function of the lacing and batten plates will be to transfer longitudinal shear from one flange to the other whenever and wherever the compressive stress is unequally distributed. The maximum value of this shear may, under certain conditions, approach the total load P on the column, and hence the total area of lacing and batten plates should be sufficient to carry this shear. This will serve as a good criterion in designing lattice columns and represents the writer's practice, though the whole subject is largely a matter of standards.

DAVID MOLITOR, C.E.

Toronto, March 20th, 1916.

Re the Constant Angle Arch Dam.

Sir,—The article on this subject in your issue of the 9th inst. is interesting and instructive and makes a good case for the constant angle arch dam.

The design of an arched dam is really a very difficult problem and the calculations of the stresses which take effect in such a structure depend upon an unusually great number of more or less crude assumptions which only have a degree of probable approximate accuracy so that the results must of necessity have a high degree of probable variation from the truth, and it is a matter of astonishment to observe that the designs discussed depend in part for their stability upon what is described as the "initial stresses." Although on the assumption of ideal conditions (rigid abutments and so forth) such stresses exist and lead to the statical relations described, yet practical considerations make these stresses casual, uncertain and unreliable for so important a structure as a high masonry dam. Most straight masonry dams show transverse cracks and they are not unknown in arched dams, and it is the exception rather than the rule to find rock masses in nature of a greater length than 16 feet, which leads to the supposition that temperature, moisture and foundation changes are sufficient—anywhere near the surface—on occasion to release the whole of the lateral extensions of rock, masonry, or concrete masses based upon Poissons Ratio. Further, in the case of a masonry dam the water in the reservoir presses equally hard upon the sides of the reservoir as upon the dam and probably pushes away the arch abutments a quite important amount. Under these circumstances, is it desirable that the "initial stresses" should be relied upon to assist the stability of a masonry dam?

W. GORE, M.Inst.C.E.

Toronto, March 16th, 1916.

Editorial

CANADIAN TIMBER IN DEMAND.

The announcement made by Lord Shaughnessy some few weeks ago in which he stated that the Canadian Pacific Railway Company henceforth will use, as far as possible, only Canadian woods, has been favorably received by the lumber interests throughout the Dominion. The company propose to use Canadian woods for construction and ornamental interior finishing of all their buildings, as well as their railway cars.

The decision is one which may be looked on as a result of efforts of the forestry experts who have been showing Canadian woods at the exhibitions held in the United States and Europe. The Canadian exhibits of woods have been very well arranged, especially the more ornamental woods which are used for interior finish. These magnificent samples have attracted the attention of the commercial world to such an extent that we may expect a big increase in their use. The most important result, however, is the fact that Canadians themselves have seen from these exhibits that it is not necessary to go far afield to secure good wood for any purpose whatever. The increasing use of Douglas fir, western hemlock, red cedar and other beautiful woods which are taking the place of the more expensive hardwoods for interior finish and cabinet work is an evidence of the timeliness of our "getting acquainted," as it were, with our own woods.

The British Columbia Forest Branch is especially deserving of credit for the way in which they have studied the market in their endeavors to supply the products which the Canadian people require. They have launched a big publicity campaign which has attracted widespread attention to the immense resources of the forests of British Columbia. More particularly they have been developing a trade among the farming communities of the West. Bulletins showing plans of various farm houses and stables have been distributed. The farmer may calculate the exact cost of the structure he proposes to build, as a detailed bill of quantities is given.

The use of timber as a structural material seems to have slipped the mind of the engineer and public alike. For years there has been a cry of "what will we do when our timber is all spent?" and the logical result has been that other materials have stepped into the breach. In most cases the substitute has been better than wood, and has perhaps, when first put on the market, been more expensive than the wooden article whose place it was filling. However, with the subsequent rise in the price of timber, due to production costs and scarcity of material, the substitute has gradually become cheaper, not only in first cost but in maintenance.

Recently the lumbering interests of the middle western states commenced a campaign of popularizing wood as a structural material. They claimed that the conservationists of the United States had so influenced the people in the conservation of wood that the lumbering industry had fallen off. Bulletins issued by the Lumbermen's Association have as their object the correction of the impression that the exhaustion of the timber resources is imminent.

According to the report of the Commission of Conservation, Canada very likely only has about one-quarter of the standing timber that our neighbors south of us have. The commission is now taking inventories of the two most westerly provinces and should have them complete in a couple of years. The total stand of timber in the whole of the Dominion of Canada should be known in about five years. When these facts are known will be time enough to boost the use of timber again as a material of construction, providing, of course, that it can compete with the present substitutes. The use of timber as an ornamental material for interior finish will, with the amount used for residences, farm buildings and other small structures, keep our lumbering interests busy enough for the next few years without cutting timber for structural purposes where its value monetarily is bound to be less than any of the materials now in use. Our American cousins can well afford to expend their timber for such purposes when they have such a supply on hand.

STRESSES DETERMINED BY MEANS OF POLARIZED LIGHT.

A number of examples showing the application of polarized light in the determination of stresses in engineering materials and structures were given by Professor E. G. Coker in a lecture before the Royal Institute, London, Eng. The application of polarized light to this use is new, but the phenomenon involved is a century old. Sir David Bennet, in 1816, discovered that transparent materials become doubly refractive when stressed. The discoverer of this property of transparent materials pointed out that stresses in the arched rings of bridges could be rendered visible in a glass model by the aid of the doubly refractive effect produced by a beam of polarized light. On account of the unsuitability of glass for modelling purposes, not much use has been made up to the present of the method. However, in recent years the advent of transparent nitro-cellulose materials, which are easily modelled by means of ordinary woodworking tools has removed this obstacle.

Simple stress is estimated, by this method, from the colors observed. For instance, the action of water in a pipe can be imitated by applying a uniformly distributed stress to the interior of a ring; the arrangement of the color bands indicates that there is a very large stress at the interior surface, diminishing rapidly at first and afterwards more gradually as the outer surface of the pipe is approached.

The new method of determining stresses, even if approximate, should be of great interest to engineers. There are some problems which are beyond solution by mathematical means, which may be solved with enough accuracy to answer immediate needs. Sometimes the design of a whole structure will be jeopardized by the improper estimation of one seemingly small item.

Too often we find that the discoveries of science have been overlooked by the engineer, who usually has very little time to delve into such things. It is the engineer who has chosen pure science as a hobby who usually finds out more about its application to engineering problems.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

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Book Reviews:

BOOK REVIEWS.

Overhead Transmission Lines and Distributing Circuits; Their Design and Construction. By F. Kapper. Translated by P. R. Friedlaender, M.I.E.E. Published by Constable & Company, London. First edition, 1915. 300 pages; 297 illustrations; 7 x 10 ins.; cloth. Price, $4.50. (Reviewed by J. H. Mackay, engineer of transmission work, Toronto Power Company.)

This volume, while written from the standpoint of European practice, should nevertheless prove a desirable acquisition to the library of most engineers interested in the design and construction of transmission lines in America.

While the fundamental principles underlying European design and construction are dealt with in a satisfactory manner throughout the subject matter of the volume, it is interesting, however, to note that the competent American engineer of to-day has paved the way in the matter of efficient long-distance, high-tension construction and transmission. The American engineer, however, gives due credit to his Swiss, French and Italian brothers who were among the pioneers in successfully undertaking and carrying out the tasks of designing, building and operating transmission lines for voltages up to 50,000 or 60,000.

The subject matter of the volume covers the entire field of operations, from the survey for the right-of-way to the completion of the line, and a careful study of the various chapters of the book cannot help but be of interest and value to the reader.

One of the most important matters in conjunction with the successful operation of high-tension transmission lines, is discussed, and illustrated by several cuts showing the various pin and suspension types in general use. The author makes the statement that the mechanical safety of the installation is increased when suspension insulators are used, as their flexibility enables equalization of stresses to take place on straight stretches and at corners, and in case a line breaks on one side of a tower, the tower will not be subjected to much stress, as the chain of insulators will set itself in a slanting position and virtually lengthen the line, thus relieving the tension in it. This statement, while true, is, however, offset by the fact that with suspension insulators the risk from a combination of sleet and wind is much in excess of that which would arise were the same line equipped with insulators of the pin-type. The former line sag depends on, or is governed by, the loading of adjacent spans, and in this connection, the present-day suspension insulator string is not an ideal arrangement.

One notes that in Europe a private right-of-way is seldom secured, and wayleave has to be obtained from possibly hundreds of small property owners before actual construction work can commence; here in America, however, after the generating and distributing points are located, the power company will make a preliminary survey of the most direct route and then purchase outright a strip of property of sufficient width to meet their present and future requirements. After the engineers have decided upon the types of supporting structures, most desirable from the points of strength and economy, then the actual survey for the tower locations is gone ahead with.

Some curves are given, based on European practice, showing approximate costs of a 20,000-volt three-phase line some six miles in length, using various types of construction with span lengths from 130 feet up to and including spans of 650 feet in length. These curves are valuable only in comparison with known cost data obtained under conditions peculiar to America.

In Europe, the initial construction work in connection with a transmission line, or distributing system, is apparently, as a rule, undertaken by contractors, rather than by the company itself, and a chapter deals with forms of agreements and schedules of prices for the various operations to be performed. This method of procedure would, on this continent, however, be open to question, as every large company has its own staff of competent engineers and workmen under its direct supervision and control.

In summing up the work as a whole, it can be said that the book is well illustrated, and the subject matter divided into proper chapters, these chapters again being subdivided under proper headings. The descriptions and numerical examples are such as can be readily understood, thus being of value to the engineer.

In conclusion, it may be noted that we in America, however, must design and build our transmission lines to meet conditions peculiar to our own continent, where the market for the energy produced may be hundreds of miles from its source, thereby necessitating voltages greatly in excess of European requirements, and again, where the temperature may be much below, or greatly in excess of that encountered in middle Europe.

Geodetic Surveying. By Edward R. Cary, Professor of Railroad Engineering and Geodesy, Rensselaer Polytechnic Institute. Published by John Wiley & Sons (Inc.), New York. 279 pages, 5½ x 8 ins., 98 figures and 21 tables, cloth. Price, $2.50 net.

The book has been written with the idea of bringing literature on the subject up to date, as during the past fifteen years some marked improvements in the practice of geodetic surveying have taken place.

The book covers reconnaisance, describing the methods of precise measurement of base lines and various corrections to be applied to angular measurements in laying out the network of triangles for the survey. A chapter on geodetic latitudes, longitudes and azimuth takes up approved methods of calculating these quantities. A great deal of attention is allotted to the instruments used in geodetic work, with methods of adjustment. Precise levelling and trigonometric levelling are dealt with fully and map projections are given a chapter.

One appendix is devoted to practical astronomy, with examples of methods of computing, time, latitude, longitude and azimuth. Another appendix on the method of least squares completes the book.

The author has described many methods employed by the United States Coast and Geodetic Survey, which represent the most advanced practice.

The book should be of particular value as a text-book for use in engineering schools, as all the subjects taught in lectures on Geodesy and Practical Astronomy are contained in the same work. Engineers engaged in geodetic work and precise surveying will find this work useful as a reference. The book is well bound and the illustrations are very good.

Practical Surveying. By Ernest McCullough, C.E., M.Am.Soc.C.E. Published by the D. Van Nostrand Co., New York. 395 pages, 5 x 8 ins., 229 illustrations, cloth. Price, $2.00 net.

The purpose of this book, the author says in his preface, is to meet the needs of students whose mathematical preparation does not extend beyond simple arithmetic. It is intended to be used as a text in high schools or vocational schools and for self-tutored men who wish to become surveyors.

Instruments used in all branches of survey work are described in detail. The chapter on chain surveying is very complete. Under compass surveying are given the use of the instrument in the field, notes on attraction and variation, balancing errors, computing lost courses and areas and plotting the map. Trigonometry is treated in simple language in one chapter, giving both the regular and graphic solutions of plane triangles, with problems; and the use of logarithms is explained. The use of the transit is taken up, and a small amount of space is devoted to stadia work. The chapter on surveying laws is very thorough, treating with the various United States laws which have to do with the surveyor.

The book is well illustrated and the language throughout is very easily understood, making it a very valuable work for students of surveying.

Forest Protection in Canada, 1913-14. Compiled under the direction of Clyde Leavitt, M.Sc.F., Chief Forester of the Commission of Conservation. Published by the Commission of Conservation of Canada. Illustrated, 274 pages, 6 x 9 ins., cloth.

The report contains much information respecting the work of the provincial forest services and of the federal departments entrusted with the care of our forests.

Forest fire protection is assuming a large place in public attention. It is obvious that, if Canada is to continue as a wood-producing country, she must conserve her resources of this natural product. The report treats exhaustively of the fire protection of forest lands along railway rights-of-way. Through co-operative action great headway has been made in securing the reduction, of forest losses through fires traceable to railway causes.

The forests of British Columbia and on Dominion lands in the West have been dealt with in reports containing the results of special studies conducted by Dr. C. D. Howe and Mr. J. H. White. The Trent watershed in Ontario has also received especial attention in a report of an investigation by Dr. C. D. Howe in the townships of Burleigh and Methuen. This district is important in that, while of very little value as an agricultural area, it is being repeatedly overrun by forest fires and the little remaining merchantable timber destroyed. It is suggested that the area be placed under the control of the Dominion Forestry Branch for protection from fires and for reforestation.

Elements of Railroad Track and Construction. By Winter L. Wilson, Professor of Railroad Engineering, Lehigh University. Published by John Wiley & Sons (Inc.), New York. 396 pages, 5 x 7 ins., 210 illustrations, cloth. Price, $2.50 net.

This is a revision of an earlier edition, with some seventy pages of additional matter and several new chapters. A chapter on the Practical Turnout, which has been written on the recommendation of the American Railway Engineering Association, is responsible for over half the additional matter. The make-up of the book is open to criticism, owing to the fact that the first 260 pages take up track and maintenance, leaving only 130 pages at the end of the book for railroad construction, trestles, culverts, etc. The very last chapter, which is devoted to "Classes of Grades," is covered in six pages, which is very short, considering the importance of this subject to the maintenance of way engineer. As the size of the train which can be hauled over any division is directly proportional to the ruling grade, and, therefore, has a bearing on the operating costs, the question of economic grades should have received more attention.

The chapters dealing with railroad construction and engineering organization should have been at the front of the book.

The author states that the book has been published as an aid to students of railway engineering to take the place of large treatises, which deal with the work more in detail than the student requires.

Engineering as a Career. A series of papers by eminent engineers. Edited by Prof. F. H. Newell, of University of Illinois, and C. E. Drayer, Secretary, Cleveland Engineering Society. Published by D. Van Nostrand Company, New York. 226 pages, 5 x 7 ins., cloth. Price, $1.00.

This book has been published as a guide to parents and others interested in technical education. The facts presented should be a guide to them or to young men who plan a career along engineering lines without knowing just what is in store for them. It explains the duties of an engineer, whether civil, mechanical, electrical or mining, and tells what qualifications the prospective student of engineering should have before commencing his studies.

The various contributors to the book have, perhaps unconsciously, written the histories of their careers.

This adds value to the opinions which they have freely expressed.

The book should be read by all high school teachers and others who are frequently asked to advise young men in the choice of a career. In a great many cases the advice given by them is founded on the most hazy ideas of engineering, and the student who plans his education on such advice only finds out, often too late, that he is on the wrong track, and his time has been wasted in pursuit of a career for which he is not fitted.

Tacheometer Surveying. By M. E. Yorke Eliot, A.M. Inst.C.E. Published by E. & F. N. Spon, Limited, London, and Spon & Chamberlain, New York. 145 pages, $4\frac{1}{2} \times 7$ ins., 1 plate and 30 illustrations, cloth. Price, $1.50.

This book is for the use of engineering students who require a book which gives information on the actual handling of the work in the field and office. Four chapters are devoted to the elementary study of the subject, and are intended to give the student a thorough knowledge of the simpler work before going into more difficult phases of it. A whole chapter is devoted to the actual field work of a contour survey, from selecting the station points to the final calculation. Another chapter gives the office work in connection with the survey. The calculation of lines and areas and the uses of the slide rule are taken up. The author states that the book has been written with the intention of explaining tacheometry as it is practised in countries outside of England and aiding in the more widespread use of the methods employed.

Railway Regulation. An analysis of the underlying problems in railway economics from the standpoint of government regulation. By I. Leo Sharfman, Professor of Political Economy, University of Michigan. Published by the La Salle Extension University, Chicago. 230 pages, 6 x 9 ins., leather. Price, $2.00.

A book presenting an analysis of the leading problems in railway economics from the standpoint of government regulation in the United States.

The historical facts are presented which have led up to present-day practice and problems. The author quotes figures which show the magnitude of the railway industry and the influence it has had on the development of the nation. The history of railroading under private development and public aid, and the evils of early speculation, are given with some detail, showing how public sentiment gradually turned against the roads. Chapters are devoted to Railway Competition; the Theory and Practice of Rate-making; the Regulation of Railway Rates; Railway Discrimination and various legal decisions of the courts on regulation of roads.

While the book has been written entirely with regard to American railroads, it would be of interest to the student of railway economics.

Elements of Highway Engineering. By Arthur H. Blanchard, C.E., A.M.Am.Soc.C.E., M.Can.Soc. C.E. Published by John Wiley & Sons, 1915. 500 pages, 6 x 9 ins., 202 figures, cloth. Price $3.

In the preface the author states that the book was written for the use of students who required only the fundamental principles and did not desire to take up a special course in highway engineering.

The first five chapters deal with highways in general. The ancient Roman roads are described. They were originally built for military purposes and declined with the fall of the Roman Empire. The reader will note how very similar were the ideas of the ancients with our own in regard to design of roads. Reference to the pioneer work of Tresoguet in France and McAdam and Telford in England is made.

Economics and methods of taxation for road improvement are discussed, with a very full description of methods in use in France. Preliminary investigation, survey and design, grading and machines are each given a chapter.

The following twelve chapters give details of different classes of roads and pavements. Development, with historical data and a glossary of terms, heads each chapter. Very little space is given to natural roads. The remainder of the book is given over to street-cleaning and snow-removal, sidewalks and highway structures, which are very lightly touched on. Useful appendices on highway terms and testing of material are added.

Industrial Leadership. By H. L. Gantt. Published by the Yale University Press, New Haven. Conn. 128 pages, 5 x 8 ins., with nine charts. Price. $1.00 net.

This book contains addresses delivered in the Page Lecture Series, 1915, before the senior class of the Sheffield Scientific School, Yale University. The author states that in his lectures he has attempted to set forth the principles on which industrial democracy can be based so as to be more effective than any system of industrialism which can be developed under autocracy. The great war is evidence of the superiority of autocracy in organizing a nation for both industrial and military efficiency, and if democracy is to compete successfully it must develop methods which will be at least equal to those employed by autocracy.

Civil Engineers' Cost Book. By Lieut.-Col. T. E. Coleman, Royal Engineers. Published by E. & F. N. Spon, Limited, London. 381 pages, pocket size, cloth. Price, $1.50.

This book is compiled for the use of engineers and contractors. Actual costs of construction for various works are given, the details for which have been gathered by the author during a long and varied experience in connection with civil and military engineering works. A chapter on cost of plant and machinery will be very useful. As a general reference book for engineers engaged in countries where English units of currency are in force it no doubt will be found very useful. For Canadian engineers, however, it will serve more as a basis for comparison of costs.

Railway Maintenance Engineering. By Wm. H. Sellew, M.Am.Soc.M.E. Published by D. Van Nostrand Company, New York. 360 pages, $5 \times 7\frac{1}{2}$ ins., 194 illustrations and 6 folding plates, cloth. Price, $2.50.

The author states that the book was written primarily as a text book for students, but that some information of an advanced character has been included that will be of value to the practising engineer as a reference book. It would be particularly useful to the location or construction engineer breaking into the maintenance department activities. In case of the reader desiring to go more fully into questions discussed, there is a bibliography at the end of each chapter which will direct his efforts along the lines of research. The first four chapters deal with construction problems; the remainder of the

book is devoted to maintenance work. Materials of construction and operation used in the various branches of maintenance are very fully discussed. A chapter on rails, dealing with standard sections, strength and methods of manufacture being particularly well written. In this connection it might be said that materials have received the greatest attention in the book, while methods of construction have been cut short.

Chapters on station buildings, fuel and water stations and icehouses are of value, the chapter on icehouses and methods of harvesting ice being larger than the others. A feature of the book which should commend itself to all maintenance engineers is that all names of makers of various appliances are given, with cost data covering some of them. Numerous tables included in the book will be of service to the practising engineer.

Electrical Pocket Book for 1916. Published by Emmott & Co., Limited, Manchester and London. 240 pages and diary, 4 x 6 ins., illustrated, cloth. Price, 30 cents.

The annual electrical publication of the "Mechanical World" series. A collection of engineering notes, rules, tables and data, with new information introduced and several sections re-written.

Machine Design. By Albert W. Smith, Director of Sibley College, Cornell University, and Guido H. Marx, Professor of Machine Design, Leland Stanford Junior University. Published by John Wiley & Sons (Inc.), New York. Fourth edition, revised and enlarged. 500 pages, 6 x 9 ins., cloth. Price, $3.00. (Reviewed by L. M. Arkley, M.Sc., Mechanical Engineering Department, University of Toronto.)

Chapter I. explains the elementary definitions used in the study of motion in machine parts without regard to the forces causing motion.

Chapter II., called "Motion of Mechanisms," treats of the relative motion of the parts of the slider crank chain, and gives in detail methods of finding the velocity of the reciprocating parts in quick return motions.

In Chapter III. analyses of several well-known straight-line motions are given.

Chapter IV. treats of cams, but in a rather brief way. This chapter could be enlarged to advantage to include such forms as cylindrical and sliding cams.

In Chapter XVII. tooth-wheels, or gears, are discussed at length and in the conventional fashion. Involute and cycloidal tooth outlines are described and methods of design of spiral and bevel gears given.

The subjects discussed in the above mentioned chapters are usually treated separately in books on Kinematics of Machines, as they deal primarily with motion without reference to force, while "energy in machines," taken up in Chapter V., comes naturally under the head of dynamics of machines.

The remaining chapters treat of machine design proper, and take up methods of design of riveted joints, bolts and screws, axles and shafts, journals and bearings, couplings and clutches, belts, ropes, brakes, flywheels, etc., and these subjects are treated in much the same manner as in all standard books on machine design. The last chapter on machine frames is one of the best in the book. In it the stresses developed in the frames of several commonly-used machine tools are analyzed and the best section for resisting these stresses indicated.

This book has probably been written primarily as a text book for students, and used as such should serve its purpose very well, especially if supplemented with exercises in Kinematics and machine design worked out on the drawing-board. From the above it will appear that the book appeals to the teacher of machine design rather than to the practical designer, who finds most useful books containing data on the subject in hand instead of a treatise on first principles.

Metal Statistics, 1916. Published by the American Metal Market and Daily Iron and Steel Report, New York. 368 pages, 4 x 6 ins. Price, 50 cents.

Is given over entirely to tables showing the prices and production of minerals, their manufactured products and various kinds of coal and coke. In most cases the tables include estimates for 1915, but in some places 1915 figures are completely omitted.

Empire Directory and Year-Book. Published by the Sanitary Publishing Company, Limited, London, Eng. 200 pages, 7 x 9 ins., and diary. Price, $1.50.

This is the 34th annual issue of the year-book of "The Sanitary Record and Municipal Engineering." A directory of municipal authorities for the United Kingdom and all British colonies and dependencies, while not complete as regards Canada, would likely be of use to Canadian firms looking for a market in Britain where the information given is more likely correct. Other information relative to municipal and sanitary engineering is given under various chapter headings.

PUBLICATIONS RECEIVED.

Mineral Production of Canada.—The preliminary report of the Mines Branch for 1915.

Timiskaming and Northern Ontario Railway Commission.—Report of the Ontario Government Railway for 1915.

Water Power Commission, Province of Nova Scotia.—Progress report, 1915, with a map showing progress of stream measurement and power investigations.

The Production of Cement, Lime, Clay Products, Stone and Other Structural Materials in Canada.—A report of the Mines Branch, giving statistics for the year 1914.

Iowa State Highway Commission Service Bulletin.—The March number of this interesting little paper, describing a new bridge at Iowa City and other Iowa road news.

Mineral Production, 1915.—Bulletin No. 1, 1916, of the British Columbia Bureau of Mines; a preliminary review and estimate of mineral production during 1915, by Wm. Fleet Robinson, provincial mineralogist.

Department of Mines.—Summary report of the Mines Branch, Ottawa, for 1914, describing investigations in connection with metallic and non-metallic deposits, testing of oils and fuels, examination of minerals and statistics.

Design of Intakes, Scroll Cases and Turbine Draft Tubes for Single Runner Turbines.—By A. G. Hillberg, hydraulic engineer, Park Row Building, New York City. A series of articles reprinted from the Engineering Record. Distributed free on application to the author.

The Colorado Industrial Plan.—A booklet by John D. Rockefeller Jr., in which is reprinted the article "Labor and Capital—Partners" and several addresses by the author respective of working conditions in the coal and iron mines of the Colorado Fuel and Iron Company.

Canada's Iron and Steel Industry.—A 14-page pamphlet, giving the history of the Nova Scotia Steel and Coal Co. Illustrating and describing the various plants and giving a synopsis of the financial affairs of the company.

Metal Mine Accidents in the U.S.—A technical paper published by the U.S. Bureau of Mines, giving statistics of accidents during the year 1914.

Some Engineering Problems of the Panama Canal in Their Relation to Geology and Topography.—Bulletin No. 86 of the U.S. Bureau of Mines. A paper by Donald F. McDonald, who was detailed as geologist to the Panama Canal while it was under construction. The paper has been published by the Bureau of Mines as a contribution to engineering literature because it presents information that shows how geology and topography must be considered by the engineer in planning excavations and in removing loose material and solid rock in the safest and most efficient manner.

Poor's Manual of Railroads for 1916.—The 49th edition of Poor's Manual of Railroads, covering the United States, Mexico and Canada, has just been issued. This valuable reference work presents this year for the first time the margin of safety on individual bonds and stocks in the form of percentage of total net earnings remaining after interest or dividends. This information appears throughout the text in connection with the statements. It gives subscribers first-hand facts upon which to base their estimates of value.

Bond descriptions have been thoroughly revised, particularly with respect to the underlying security. In this work, the Manual has had official assistance. The descriptions contain new italicized headings, such as Interest, Trustee, Secured By, etc., so that the particular kind of information wanted may more readily be found.

All statements are revised to June 30, 1915, including those of companies that report for the calendar year. Information of importance issued prior to February 10, 1916, is also included.

CATALOGUES RECEIVED.

The Milburn Light.—A 52-page, illustrated catalogue describing the various styles of lights and other products manufactured by this company.

Tiffin Motor Trucks.—A very attractive four-page pamphlet giving the specifications of this well-known line of motor trucks. Suitably illustrated. Tiffin Wagon Company, Tiffin, Ohio.

Centrifugal Pumps.—Bulletin No. 108-A issued by the Wheeler Condenser and Engineering Co., Carteret, N.J., being a 34-page catalogue describing their single-stage, double-suction, type D.A.A., centrifugal pump for heads of 0 to 300 feet. Well illustrated.

PERSONAL.

R. C. D. TEMPEST has resigned from his post as resident engineer of the sewer section, Toronto, on account of ill health.

K. H. SMITH, B.A.Sc., recently addressed the Nova Scotia Society of Engineers on "Some Engineering Features of the Pan-Pacific International Exposition."

JOHN KEILLOR, gas engineer, Hamilton, Ont., has received the appointment of superintendent to the Vancouver Gaslight Co., Vancouver, B.C. Mr. Keillor was previously manager of the Hamilton Gaslight Co.

B. G. SLAUGHTER, late vice-president and chief engineer of the Canadian Copper Company, Copper Cliff, Ont., has resigned to accept a position as vice-president of the Tennessee Copper Company, Copperhill, Tenn.

OBITUARY.

WM. W. CHISHOLM, electrical superintendent of the Wallaceburg, Essex and Lake Shore Electric Railway, was electricuted while working around a derailed car near Leamington.

CHARLES SELLERS, president of the Peerless Furnace Co., Toronto, which he founded over twenty-five years ago, died on March 20, aged 82. Mr. Sellers was a native of Glasgow, Scotland, but had resided in Toronto for over 60 years. He was superintendent of the Gurney Foundry Co. for more than 20 years.

OTTAWA BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a luncheon of the branch held recently, E. A. Dunlop, M.L.A., gave a very interesting address in which he described conditions at the front as he saw them on his recent visit to the trenches. Mr. Dunlop spoke particularly of the work of Col. Mitchell, head of the Canadian Intelligence Department. Mr. Dunlop was accorded a hearty vote of thanks for his interesting talk.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MONTREAL.

An instructive illustrated lecture and practical demonstration on the subject of "Electrical Precipitation of Solids from Grease," was given by Linn Bradley, of the Research Corporation, New York, before a large gathering of the members of the Canadian Society of Civil Engineers, in the Macdonald Engineering Building.

The lecturer treated with the importance of the subject to every branch of the engineering profession as regarding mining, metallurgical, chemical and electrical industries.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a dinner of the members of the branch a very interesting talk was given by G. N. Houston, of the irrigation branch. Mr. Houston spoke on "Legislative Control of Engineering Practice." He stated that there was a growing attempt to control the practice of engineering by legislation on both sides of the line. Several engineering societies had attempted to have legislation passed which would state the qualifications required of a man before he could practise as a civil engineer. The bills had, however, been defeated. Until some definition of the term "civil engineer" was arrived at the public would not be protected from incompetent engineers.

The speaker doubted if licensing would cut out incompetence. He proposed in lieu of law that the government supervise all plans and specifications for construction, and also admit as members only men of a very high grade.

"The man to be admitted should be a member of the Canadian Society or British Society, or a society of equal standing or certificate," concluded Mr. Houston.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

IMPACT FORMULAS FOR HIGHWAY BRIDGE DESIGN

PART I.

A BRIEF HISTORY OF TWO RAILWAY BRIDGE IMPACT FORMULAS, SHOWING THAT THEY ARE UNSUITED FOR HIGHWAY BRIDGE DESIGN.

By E. H. DARLING, M.E., A.M.Can.Soc.C.E.

OVER a hundred years ago, in 1807, Thomas Young first announced the general principle of the properties of bodies "to resist impulse." This property, to which he gave the name "Resilience," is the capacity of a body to endure, absorb, or store up the work which may be done on it and give it out again under proper conditions.

As a simple example of this, when a tensile force is applied to a bar of steel, the bar is extended and work is done by the force. The work is absorbed by the bar and by the law of conservation of energy the internal work in the bar must equal the applied external work. When the external force is removed the bar assumes its original length, giving out as it does so the stored-up work which is, by definition, the resilience. Wherever in engineering structures there is compression, extension or deflection (provided the elastic limit of the material has not been exceeded) we have examples of resilience.

This property is of the utmost practical importance in engineering. Were it not for it a structure, no matter how strong under static loads, would be liable to be shattered by a light blow. Glass is an example of a material with low resilience and we are quite familiar with its "brittleness" and its inability to withstand a shock. But even a bar of iron or steel can be broken with a surprisingly small amount of work. A bar of steel having one square inch section area and a modulus of elasticity of 29,000,000 will require only 17.6 foot-pounds of work to stretch it to its elastic limit of 32,000 lbs.

If the bar were 10 feet long or 10 square inches in section it would take ten times as much work to stress it to the same point. So that the resilience of a bar or a bridge member varies as its section and length, or, which is the same thing, as its volume.

But the absorption of work is not quite instantaneous, although very rapid. Stress is said to travel in steel at the rate of about 17,000 feet per second—the same rate as sound. Rapid as it is, it is still slow enough to make it an important consideration. If the force be applied to the bar instantaneously by striking it a blow it is possible to stress the metal at the point of contact beyond the elastic limit or even the breaking point before the rest of the bar can absorb the work.

After Young, there was considerable investigation and discussion of the subject, but it was first put into practical form, as far as the engineering profession is concerned, in 1849, when an extensive series of tests was made in England by a "commission appointed to inquire into the application of iron to railway structures." The result of their report was that the British Board of Trade established the rule that for cast iron the factor of safety for live loads should be double that for dead loads. This rule was largely used for many years and became accepted as a general principle to be applied to live loads of any kind or however applied. It is based on the fact that a suddenly applied load, *i.e.*, one which reaches its maximum value the instant it is applied, does produce twice the stress in a structure that it would if it were applied gradually.

If a tensile force p be applied suddenly to a bar and extend it a length λ the work performed on the bar will be $p\lambda$. But in absorbing this work the stress in the bar increases from zero to p_b so that the work absorbed equals $\frac{p_b\lambda}{2}$.

As the internal work equals the applied work

$$p\lambda = \frac{p_b\lambda}{2} \text{ or } p_b = 2p$$

If the force were applied gradually p_b would equal p.

All the experiments of the above-mentioned commission were performed on cast iron and the experimenters failed to detect the elastic limit of the metal, as in this material it is so near the breaking strength. Besides, testing machines did not reach a sufficient degree of refinement to permit an accurate study of materials under stress until thirty years later. The commission, however, detected a phenomenon in materials subjected to repeated stresses which was called "fatigue." This subject was carefully investigated by Woehler between the years 1859-1870, and he established the principle that when a bar iron was subjected to a varying stress a number of times (sometimes it took an enormous number) it broke at a stress less than its maximum strength, as shown by a static test. This stress he expressed as a function of the ratio of the maximum and minimum stresses.

His principle was at once adopted in the design of iron bridges and was made applicable by suitable formulas by Launhardt and Weyranch. These formulas replaced the simple method of doubling the live load stress and they persist to this day in one form or another.

The fallacy of this method lies in the fact that Woehler's principle applies only to materials stressed beyond the elastic limit and it does not apply, and has no meaning, if the stress is below this point. As some one has said: "If we were designing a structure so that it would *fail*, then Woehler's formulas would be the correct

ones to use." However, the early designers were consistent to this extent, that they worked with the ultimate strength of their materials but took care to apply a sufficiently large factor of safety to bring their working stresses within the elastic limit.

Another fault of this method is that it confuses "fatigue of material" with stresses due to sudden loading. Fatigue is the evidence of "permanent work" done on the material while the impact formula in bridge design is an attempt to express the stresses caused by "temporary work." Impact is a property of the applied force depending on the way the load is applied, and it is only when resilience of the material is destroyed that fatigue appears.

But to return to our history. It was Bauschinger who proved that Woehler's rule did not hold good below the elastic limit, and in 1877 Prof. Winkler, of Berlin, first suggested that the dynamic effect of the live load should be considered in addition to its static effect. (Trans. Am.Soc.C.E., Vol. 41, p. 172-174.) In other words, his suggestion was that the effect of impact should be treated as an increase in the live load rather than a mechanical effect on the material of the structure.

The effect of simple impact on a bridge may be roughly analyzed if the word is used in its correct sense, meaning the effects due to the stopping of a moving body. When such a moving body strikes a bridge the kinetic energy or work stored in it must be dissipated in one way or another. There are three stages in the process. First, the motion of the moving body will be imparted to the particles of the structure and set them in motion. If the structure were free to move and perfectly rigid in itself all the energy would be thus transferred according to the laws of motion. Only such stresses would be developed as would be necessary to transfer the motion to the distant particles of the structure. However, as bridge structures are not rigid and are anchored to their abutments the particles move as far as they can and the total effect is what we recognize as deflection. This is the second stage. Some parts will be compressed and others stretched. Even the abutments are never absolutely rigid and will therefore also be affected. By this action the structure absorbs work and the process goes on until the sum of the internal work equals the work imparted by the moving body. But this is not a state of equilibrium, so a series of oscillations or vibrations begins which lasts until all the surplus energy has been converted into molecular work or heat. If at any instant the stresses in any part of the structure exceed the elastic limit, permanent work will be done and the structure will not regain its original shape. Its capacity to absorb work—its resilience—has been exceeded and it cannot give back all it received.

When a train moving at a high rate of speed passes over a railway bridge there is doubtless increased stresses due to sudden loading as defined above. There are also innumerable blows, shocks, jars, etc., too complicated for analysis. The result is that stresses are produced above those that the train would cause if at rest on the bridge. This difference in stress between what would be the static stresses from the live load at rest and the actual stresses, however produced, is what is covered by the "impact increment" of modern specifications.

Joseph M. Wilson in 1885 first introduced in America the method suggested by Prof. Winkler, but the most widely used formula was first brought into systematic use by the late C. C. Schneider and published in the specifications of the Pencoyd Iron Works in 1887. (Trans. Am. Soc. C.E., Vol. 34, 1895, p. 331-2.) Mr. Schneider had collected some data of experiments on existing bridges to ascertain the effect of passing trains and from this he developed the formula

$$I = L\left(\frac{300}{s + 300}\right)$$

In which I = impact increment to be added to the static live load stress L; s = loaded length of span producing the stress L.

It is an interesting fact that since then the American Railway Engineering Association, after making thousands of measurements on existing bridges, recommended this formula, and it is now widely used in railway work.

It will be noted that in this formula the value of I, the impact increment, depends only on s, the span length, or that part of the span which, when loaded, produces the maximum static stress. For a train moving at a uniform rate of speed the length s will determine the time required for the live load to reach its maximum, so that the value of I really varies inversely as the time required to apply the load and thus takes care of sudden loading. Also, as the longer spans will usually have the longer members this formula may be considered to insure that short members have a larger impact increment than the long ones. No account is taken of the inertia of the structure nor the relative mass of train and bridge since it is used for all types of spans and for this reason many engineers were not satisfied with it but favored a formula developed by Henry S. Prichard.

Mr. Prichard derived his formula by "starting with Launhardt's and modifying it to accord with the results of a study of all data bearing on the subject which was available," and in 1895 published it in the revised specifications of the New Jersey Steel and Iron Company. (Trans. Am. Soc. C.E., Vol. 41, p. 503.) This formula is

$$I = L\,\frac{L}{L + D}$$

I = impact increment;
L = live load stress;
D = dead load stress.

The impact increment in this formula depends only on the relative magnitudes of the dead and live load or, in other words, the relative mass of the bridge and the train. No account is taken of the speed at which the train is moving, or the length of span. In later specifications which use this formula, such as the Dominion Government, 1908, in order to correct this defect, the live load stress is first multiplied by a factor varying with the length of span and the product is used as L in the above formula. The factor is

$$\left(1.40 - \frac{s}{200}\right)$$

This is only used for spans under 80 feet.

It will be interesting to compare the relative values of the impact increment as obtained from these two formulas. In order to do this the values of I, as given by them, have been plotted as curves in Diagram 1. The ordinates give the values of the impact increment in percentage of the live load for spans up to 200 feet. As the Prichard formula depends only on the ratio of the dead and live load, two curves are shown—for dead load equal to zero, and for dead load equal to live load.

It will be noted that the Schneider formula gives values about an average between the other two curves. In actual design the relation between the dead and live loads is such that the results are about the same whichever formula is used, except for very short spans and heavy loading, under which conditions the Prichard formula gives higher values. The Dominion Government formula gives much higher values for spans under 80 feet.

After all, this similarity of the two formulas is what one would expect when it is remembered that they are both empirical formulas based on measurements and experiments made on railway bridges. This is the point that the writer wishes to emphasize. It at present seems utterly impossible to express by means of a rational mathematical formula the effects of shocks, blows, jars, etc., which will be generally true for all structures and all manner of moving loads. Given a certain uniform type of structure and method of loading, it is quite possible to obtain a factor or formula which will give more or less accurately the equivalent static stress for moving loads but it would be rather a strange coincidence if the formula thus obtained for railway bridges should be found to be in any way suitable for any other structures, such as highway bridges not carrying street cars. Until it has been shown conclusively that railway bridge formulas or some modifications of them are generally true for all bridges they should not be so used, for the conditions of loading are very different, as may be seen from the following detail comparison.

The impact increment in the design of railway bridges is supposed to cover the stresses produced by the following conditions:

(1) True impact due to sudden loading caused by the maximum engine and train loads travelling at a high speed.

(2) Pounding of unbalanced parts of the drive wheels, etc.

(3) Pounding of wheels at open joints and of flat wheels.

(4) Swaying of engine and top-heavy tender and other loads.

(5) Vibration and jarring of machinery in motion; the "noseing" of the engine and jolting of cars.

(6) Rhythmic motion set up in the structure due to the synchronism of the blows from the train with the period of vibration of the bridge.

(7) Every other uncertainty in the magnitude of the loads and their application, including possible derailment and future increase.

Effects somewhat similar to these will doubtless be produced in highway bridges by their loads, but the conditions are so entirely different that the results are quite modified. We have the heavy concentrated load producing maximum stresses in the floor beams, stringers and short spans; and the uniform or distributed live load of a much smaller order of magnitude which develops the maximum stresses in the trusses of spans above a certain length. But their liability to cause impact stresses is not the same as a train passing over a railway bridge, as a comparison with the above items will show.

(1) It is not necessary to consider such a thing as true impact due to high speed for a highway bridge. The experiments of the committee of the American Railway Engineering Association, mentioned above, found that impact stresses were inappreciable for speeds below 30 miles an hour. In highway traffic the only live load that exceeds this speed is the motor car. But the heaviest motor car is so much lighter than the road roller for which provision must be made that there is, in a properly designed bridge, an ample factor of safety for the high-speed car. It is true that the 20-ton motor truck is in sight, but its speed is about 10 or 12 miles an hour, and it is far from likely that they will be permitted to travel on highways at the rate of 30 miles.

(2) There is no analogy in highway bridge loads to the pounding of unbalanced drive wheels of locomotives. This is a very important consideration in railway bridges.

(3) The bumping of heavy loads over rough floors, stones, etc., may be compared to the pounding of wheels at open rail joints, but the conditions of highway bridge floors are often such as to aggravate this effect relatively beyond anything that occurs in a railway bridge.

(4) There is the same analogy in swaying of top-heavy loads, but this effect is also associated with the

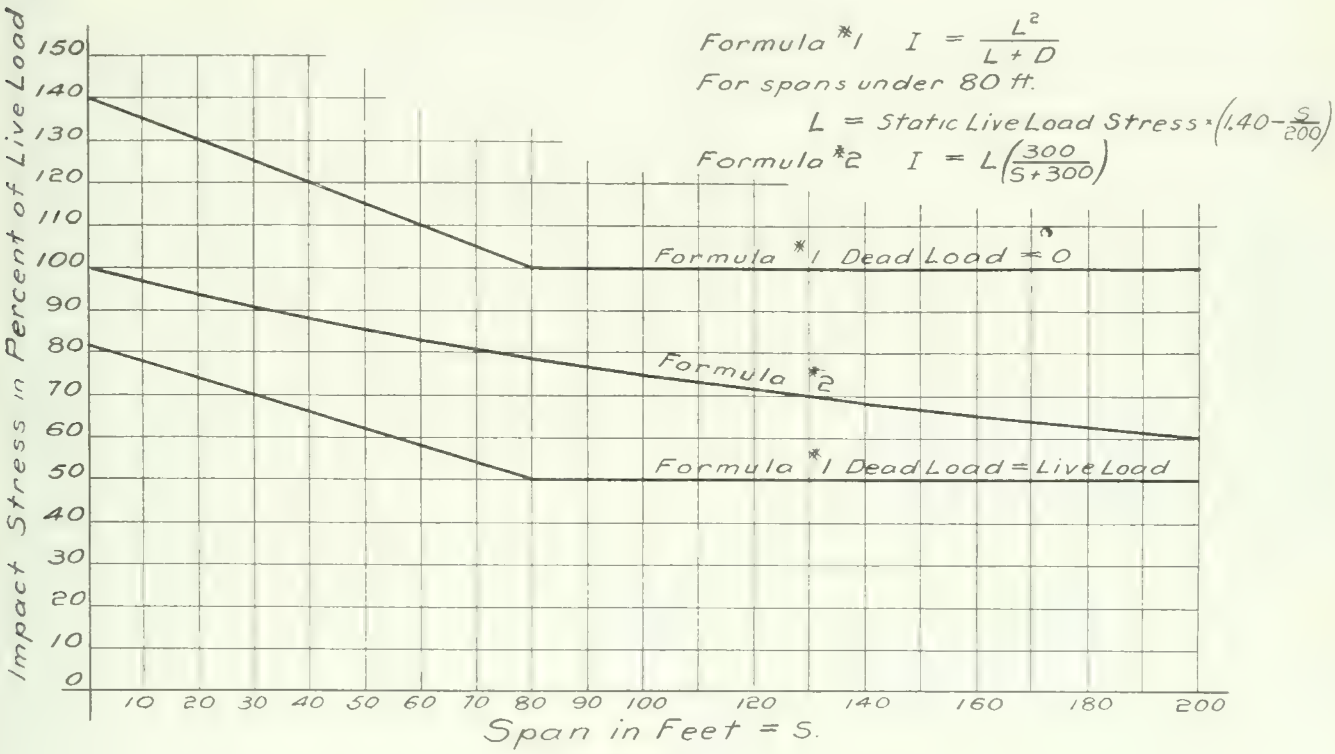


Diagram No. 1.

[illegible]ted load and cannot affect the truss of any but short spans.

(5) Vibration, jarring, jolting, etc., apart from that covered by item 2, need not be considered in highway bridges.

(6) Rhythmic motion set up by the uniform live load on long spans is a possible contingency. In spans which are relatively long for their width there is likely to be a swaying effect in a high wind. Stresses caused by these conditions are probably the only kind of impact stresses that need to be considered in the trusses of highway bridges.

(7) Much uncertainty exists as to actual stresses in highway bridges as well as in railway bridges, but it will be generally admitted that the uncertainties in the former are within much narrower limits than in the latter.

In consideration of all the above facts, it seems to the writer to be quite evident that the question of impact in highway bridges should be considered by itself and that the present methods and formula (at least those commonly used in Ontario) are wrong in principle. How they work out in practice will be discussed in the second part of this paper to be published in a future issue.

A NEW EXPANSION JOINT.

The Barrett Company is now putting on the market a new expansion joint for use in connection with concrete or brick or block pavements. This joint is mastic in character, comes in ribbon form and a variety of widths and thicknesses. The requisite cohesiveness to stand handling and storage in the ribbon form without affecting the elasticity that is necessary for expansion requirements, is given to the material by a new process known as the "fibre weld." The material is waterproof, weather-proof, and is not injured by street acids or automobile oils. Furthermore, it does not become brittle with age or cold weather, and on the other hand, does not soften or run when the weather is hot. Its chief advantage over the usual poured bituminous joint is the elimination of pouring or heating apparatus, which means a great reduction in labor, as it takes but very little time to unroll a joint, cut it and put it in position.

"CANADIAN-MADE ASPHALT."

The refinery of the Imperial Oil Co., Limited, now being built in Montreal, will be, after its construction, the only asphalt refinery in the Dominion of Canada. In the past, practically all the asphalt was of foreign manufacture. The new refinery, which will be one of the most modern and best equipped ever constructed, is for the refining of crude asphaltic oils of the highest grade exclusively, producing thereby the best material possible for the making of asphaltic roads. The equipments of the plant consist of 14 large crude oil stills, many special reductors, and pressure distillators and agitators, and a special factory for the manufacture of metal containers in which, with the aid of tank cars, the material will be shipped. The plant will have a capacity for crude and manufactured products of over 600,000 barrels.

The refinery is located at Montreal East, on a piece of ground containing more than 55 acres, fronting the St. Lawrence River. The property runs over one mile north, crossing Notre Dame Street to above the Canadian Northern Railway Co.'s tracks. The company has on the river front its own wharf, the depth of water being sufficient to permit ocean-going tank vessels, transporting crude oil, to dock at the wharf. The shipping facilities by waterway, either in bulk or in packages, are of a great advantage.

As to the shipping by rail, the Imperial Company has the Canadian Northern Railway and the Montreal Tramways Co. at its disposal, and later will have the Harbor Commissioners' Railway.

This modern installation represents an expense of more than $1,250,000, and when in full operation should employ at least 3,000 men.

TYPES AND COSTS OF SLACK CABLE EXCAVATOR PLANTS.

A FEW years ago the slack cable method of excavation was not well known, and was used only in a few isolated places. Lately, there have appeared on the market, however, a number of excavators employing this principle, and the idea is becoming more popular. This type of excavator, which has been described by A. A. Smock in The Contractor, consists of four essential parts: (1) the bucket; (2) the cable upon which the bucket is hung; (3) the mast, to the top of which the slack cable leads; (4) the engine that controls the operation of the outfit. There are numerous buckets for this use, each designed under some special patent and possessing features that distinguish it from others.

The excavators may be used for soil stripping, handling of coal, ore, rock, or other loose material, and especially for gravel excavation. The increased amount of concrete work in the last few years, together with the popularity of the gravel road or "pike," has caused a great demand for sand and gravel. This was formerly supplied in two ways; first, and most primitive, by driving a wagon to the nearest open pit and loading it by hand; second, by railroad shipments from source of supply to the nearest sidetrack, where it could be unloaded and hauled to the work. The latter method was and still is expensive on account of freight rates, and the former method is becoming less common because these neighborhood pits are gradually being excavated down to the ever-present water, from below which it cannot be removed by hand.

Naturally, the upper layers of gravel above the water are more or less dirty, while that below the water is cleaner when removed. The slack cable excavator can easily remove this gravel from almost any depth and therein lies one of its chief advantages.

The operation of the outfit is very simple, and is under the control of one man. The bucket is brought in by a "drag" cable on the front drum of the hoist, and the track cable is made loose or tight, as desired, by a "tension" cable, which passes over a pair of double blocks, increasing the pulling power of the engine about five times, which is sufficient to tighten the track cable until the bucket is raised clear off the ground. The bucket is drawn in to the dumping point, at which there is generally some device attached to the track cable, causing the bucket to discharge its load, after which it is released, rolling down the tight cable by gravity. The cable is then loosened, allowing the bucket to rest on the ground in its natural digging position ready to repeat the operation.

The power must come from some kind of a double drum hoist, either steam or electric. The most popular size is the one-yard bucket, which is generally operated by an ordinary contractor's double-cylinder, double-drum hoist, sixe 8 x 10, although smaller engines will suffice in easy digging. If electric power is used, the best hoist is a direct-connected one with a system of gears enabling the bucket to be drawn in slowly with great power while loading, and then to be drawn up to the dumping point more rapidly with less lower. In this case, a 50-horse-power, variable-speed motor is sufficient. In occasional plants where electricity is low in cost, the bucket is sometimes operated by means of a hoist which is belt-connected to a 60 to 70-horse-power motor, the larger size being required on account of the loss due to belt slippage, and also on account of the motor running at a constant speed.

The average time required to make a complete trip with the bucket is found to vary a great deal, on account

of the difference in the material, the speed of the engine, and the skill of the operator. The average outfit uses the ordinary hoist engine, which has a speed of about 200 feet per minute. Thus on a 400-foot span, 2 minutes are required to haul in the bucket and about 1 minute to dump it and return it ready for another load—3 minutes per trip. This will be found to be a very conservative figure, for many plants run as high as 40 trips per hour. Much time can be saved by using a two-speed hoist, arranged to run at about 150 feet per minute under a heavy pull, and at about 450 feet per minute under a lighter pull, thus bringing in the bucket in 1 minute instead of 2, and enabling the operator to get out 30 buckets per hour under similar conditions.

The commonest form of gravel plant is the "bar run" outfit. This consists merely of the bucket, cables, mast and engine, digging the gravel from a pit or creek-bed and depositing it on the ground in a pile. Many such outfits are in use in various locations, and are generally called "gravel dippers," the owners, as a rule, making a business of "dipping" gravel for townships, road supervisors, contractors or private individuals.

In or near cities where strict specifications are enforced regarding the gravel used, it is customary to erect screening plants to wash the sand and gravel thoroughly and grade it into sizes. These plants present an interesting study, but it is not our purpose to enter here into a discussion of their details of design and construction. There are many kinds of screening outfits, the simplest kind having an elevated table upon which the gravel is dumped, and from which it is washed by a stream of water through an inclined trough, in its course passing over inclined screens that give the required separation. The most complex plants with the greatest output and most efficient operation are more expensive, being equipped with revolving screens, washing tanks, crushers, overhead bins, etc. Between these two limits there are endless varieties of screening outfits.

Cost.—The following estimates of the cost of plants are based upon new material throughout, although in actual practice much second-hand but serviceable material is used, such as old lumber, second-hand cables, and engines. The "bar run" outfit, with a one-yard bucket, costs, complete, including a reasonable allowance for freight, erection, etc., about $2,250, while a screening plant of the more simple type, including a water pump and the screen towers, will be about $3,000, which is subject to increase on account of bins, crushers, etc., to sometimes as high as $10,000.

Operating Cost.—The average bar run outfit, with a one-yard bucket, can easily excavate, with the ordinary engine and engineer of average ability, 250 yards per 10-hour day, often running much higher or lower according to conditions. Many plants hire only one man, who tends to his own boiler, as well as making all minor repairs. It is economy, however, where results are desired, to employ an engineer, fireman and a laborer. The daily costs will be as follows: Engineer, $4; fireman, $2.50; laborer, $2; coal, $3; oil and miscellaneous, $1.50. Total, $13.

The yearly fixed or overhead charges are ordinarily not computed, but should be for an accurate notion of the business. They are as follows:

Interest on $2,250 at 6 per cent.	$135.00
Renewal of cables, blocks and sheaves	400.00
Depreciation of engine	200.00
Depreciation of bucket	150.00
Total	$885.00

The depreciation items are as a rule replaced by the actual money spent on repairing the outfit.

Counting out Sundays and days when no work is done on account of weather, it is safe to figure a year at 200 days.

200 x $13 daily pay roll, etc.	$2,600.00
Annual charge as above	885.00
Total	$3,485.00
200 x 250 yards	50,000 cu. yds.
Total cost per yard	7 cents

As an actual matter of fact, the cost at most plants is much more than this. Sometimes the men are paid yearly, whether they work or not. Frequently there is not enough business available, so that, instead of operating steadily and excavating 50,000 yards, 20,000 or 30,000 yards will be the year's business, costing 12 to 17 cents per yard.

Screening Plants.—These plants require more careful operation, and as they are generally dependent upon the retail trade near cities and towns, the output is determined not so much by the capacity of the plant as by the amount of sales made. The daily expense is greater, on account of the attention necessary to keep the screens clean, operate the pump, dispose of boulders, etc., as well as the necessity of maintaining some sort of an office and a set of accounts. In view of these facts, the above figures will be modified as follows:

200 x $15	$3,000.00
Annual charge	1,000.00
Accounts and collections	1,000.00
Total	$5,000.00
Annual sales, average	30,000 yards
Cost per yard, screened gravel	16⅔ cents

This figure is very conservative and can be attained by proper management of a plant. At the customary retail prices of 35 cents per yard, a profit of $5,500 per year results. As most plants are managed by the owner, this sum represents his salary and profits for the year.

A large plant, with a capacity and a demand for 400 yards per day, running at full capacity, will put out screened gravel for as low as 10 cents per yard, and is a very profitable business.

RAILWAY EARNINGS.

The following are the railway earnings for the first three weeks of March:—

Canadian Pacific Railway.

	1916.	1915.	
March 7	$2,198,000	$1,667,000	+ $531,000
March 14	2,258,000	1,731,000	+ 527,000
March 21	2,281,000	1,738,000	+ 54[illegible],000

Grand Trunk Railway.

March 7	$ 992,026	$ 852,151	+ $139,875
March 14	957,542	857,147	+ 100,395
March 21	967,233	857,037	+ 1[illegible]

Canadian Northern Railway.

March 7	$ 540,200	$ 428,700	+ $111,500
March 14	538,000	412,000	+ 126,000
March 21	540,000	421,700	+ 127,[illegible]

A decrease of 44 per cent. in the operating costs for the Schenectady, N.Y., garbage plant is expected this year. The difference is accountable to reduction of working staff and efficient management.

MOVING A SAND BIN.

By E. P. Muntz.

THE accompanying four illustrations show the various stages in the moving of a large stone and sand bin at Lock No. 2 on the Welland Ship Canal. The bin is 50 feet long by 30 feet wide, 30 feet high, and is capable of holding 250 cubic yards of sand and a similar amount of stone. It supplied the aggregates for concreting operations at Lock No. 2 during the latter half of last summer. A relocation of the concrete plant has since been decided on to mix the remaining 200,000 cubic yards required. This necessitated the removal of the bin from its position alongside the construction railway, opposite the south end of the lock, to a point about 1,000 feet further north and at a 30-foot lower elevation.

The construction railway parallels the canal centre line at Lock No. 2. On the west slope of the lock pit a track lies between the construction railway and the top of the slope. This track was used by the contractors to haul the dry material from the bin to the mixer; the mixer being situated towards the north end of the lock on the top of the slope and about 800 feet from the bin.

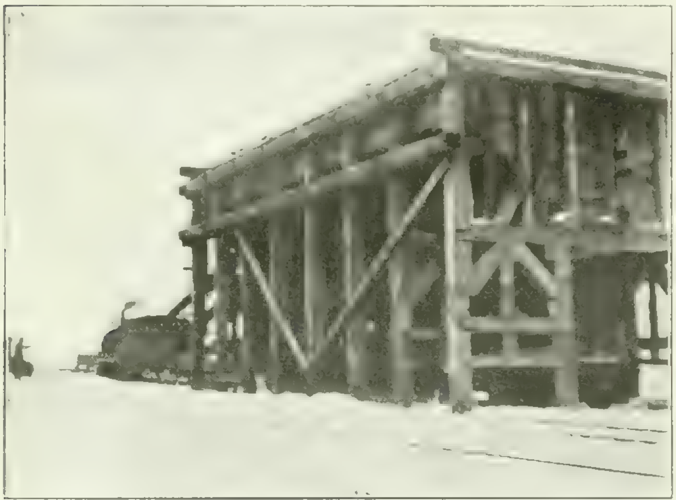


Fig. 1.—Hauling on the Level. The Double-track Railway is in the Foreground.

The moving was accomplished by jacking the bin up about two feet to permit a 60-ton steel gondola car to be run under it, on the loading track mentioned above. The weight of the bin was estimated at about 60 tons. Beams were laid across the top of the car to carry the bin and cables were used to tie the bin down to prevent swaying. The steepness of the incline (shown in Fig. 4) onto the trestle, which is the final location of the bin, necessitated the placing of a racking cable and inclined struts in the car to prevent the bin sliding.

The car carrying the bin was moved quite readily by the 45-ton Kingston locomotive, shown in Fig. 1. The track was far from being in good condition and in one place, where it lay directly on the top of the slope of the lock pit, a flat car loaded with "plums," set on the construction railway, was used as an anchor to prevent the bin overturning. Elsewhere, any tendency to upset was taken up at once by the legs bearing on the ground, the clearance being but a few inches.

The bin was lowered down the incline onto the trestle by means of two sets of blocks and tackle; the two together capable of lifting 80 tons. The free ends were secured to two locomotives, one south and one north, on the construction railway. Two heavy "dead men" held the blocks at the top of the incline. The bin was lowered by signalling the engines to come together. The rigging

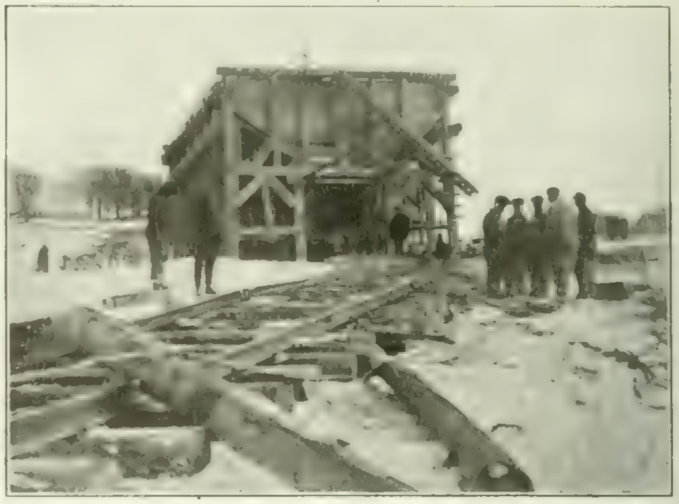


Fig. 2.—Starting Down the Incline. The Track Shown is a Siding from the Construction Railway.

of the lowering tackle and the moving and lowering of the bin took about a day and a half.

The whole operation was performed without a hitch. The bin was run out from the bottom of the incline to the end of the trestle and jacked up again and the car then hauled back.

The top of the bin is now at about the same elevation as the top of the slope on which runs the construction railway. The trestle is to be built to the same level between the bin and the slope, so that cars can be brought out from the construction railway and dumped directly into the bin.

Two 2-yard Ransome mixers are to be installed under the bin. They will be fed direct from the bin and

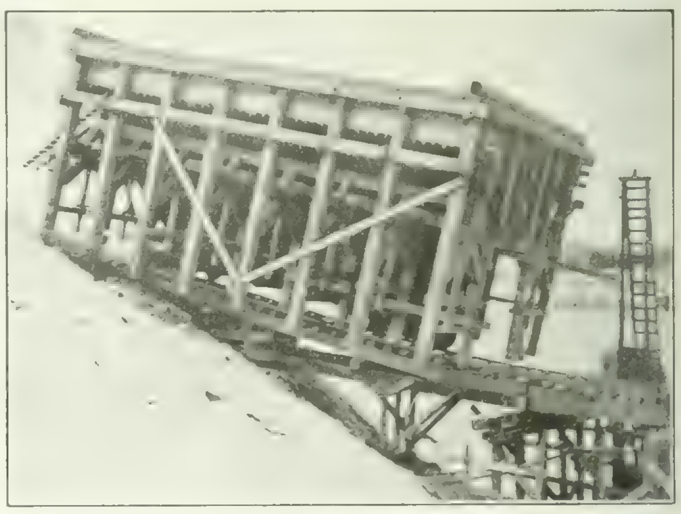


Fig. 3.—Hauling Bin Over Uneven Ground.

will feed direct into buckets on the concrete trains. The concrete trains will run through the trestle at a point directly below the position of the boom of the McMyler crane shown in Fig. 4. The trestle itself and the sub-

structure carrying the bin is built of piles driven about 10 feet to refusal. The trestle is built on the bottom of the canal below Lock No. 2.

The work being carried on at Lock No. 2 is part of section 2, of which Messrs. Baldry, Yerburgh and Hutchinson are the contractors and Mr. H. M. Balfour the resident engineer under Mr. J. L. Weller, C.E., engineer-in-charge for the Department of Railways and Canals.

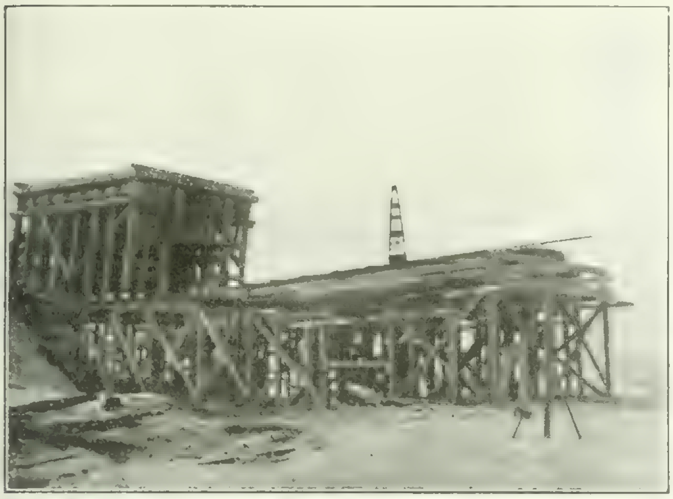


Fig. 4.—Showing Steepness of Incline onto Trestle, which is the Final Location of the Bin.

THE USE OF DREDGES IN EXCAVATING OPEN DRAINAGE DITCHES.

SOME practical notes from a paper read before the Iowa State Drainage Association by A. L. Goldenstar, of Mankato, Minn., will be of interest to engineers in this country inasmuch as the employment of dredges for the work has received very little attention here. The use of dredges has influenced the design of the ditch to some extent. Engineers have specified a cross-section which can be efficiently handled by the machine. It usually has been a section with rather wide bottom and steep side slopes. Side slopes of ½ to 1 have been very common and some have been even steeper. The arguments in favor of such a section have been that the sides were expected to cave down and the ditch would finally assume a section of its own that would stand, and second, that there would be little trouble in getting a contractor to dig the required section, because it is the easiest and most natural one to cut with a dipper dredge. But instead of the channel becoming an ideal one the sides are always rough and ragged, never cease caving in and the ditch fills up above grade clogging up the tile outlets that may be in it. The argument that nature will form the proper form of channel seldom holds good.

For the ordinary soils of northern Iowa and southern Minnesota, 1 to 1 should be the minimum slope and 1½ to 1 is often better. For loose, sandy soils even flatter slopes than these should be used. In order to avoid excessive top widths with these flatter slopes the bottom may be kept comparatively narrow. This will aid in making the ditch self-cleaning. In standard railroad and highway construction the slopes for excavation in cuts are never less than 1 to 1 and 1½ to 1 is now commonly specified. The slopes of railroad and highway cuts are exposed to even less erosive forces than the sides of open ditches.

But the proper construction of an open drainage ditch does not begin and end in specifying the right cross-section. Means must be taken to create absolutely the form that is desired. Where teams and scrapers can be used it is comparatively easy to secure smooth sides and bottoms without much hand labor. But teams and scrapers can be used in very few places so we must reckon with the dipper dredge or the dragline machine. Dipper dredges cannot cut a smooth enough or true enough side slope or bottom without the help of hand labor. Then, also, these machines are usually started at the upper end of a ditch and proceed down stream. There are only two arguments in favor of this method of procedure. The first is that it insures a good supply of water that will lubricate the dipper and make dumping easy, and the other is that it provides the necessary amount of water to float a floating type of machine. From all other points of view this method is detrimental to the job. The machine is always digging under water so that the operator can never see what kind of slope he is digging. When the dipper full of material is raised up through the water all the loose particles will wash off to remain suspended in the agitated water until the machine has moved on. Then this matter settles to the bottom in the form of silt. The author has seen from 2 to 4 ft. of this silt in a semi-liquid condition behind a dredge. It is usually assumed that this will all wash out with first flood, but it never does. Keeping the ditch full of water makes trimming of the sides by hand or any other means impossible. The wet plastic material dropped on the spoil banks settles so firm and tough as to make subsequent spreading very difficult.

The dragline machine seems to be coming into more general use now for wide open channels. Greater care can be taken with this type of machine in cutting the true cross-section channel. The sides can be left smoother since a wide flat bucket is used. Also, the spoil can be dumped over a wider area which reduces the amount of spreading.

Other types of excavator are being used, but only in a few cases. The so-called "template" excavators are made but experience with them is very limited in this territory. They still seem best adapted to dry land work.

In the light of the experience we have had with the various dredging machines, we can say that there is room for much improvement. The dredging machine is still to be invented that will by its own work, without assistance, make a first-class open drainage ditch. The kind of ditch needed is the common sized channel with from 4 to 16-ft. bottom. For the larger channels the present machines may suffice, but for the smaller ones they are not satisfactory.

The first logical step to be taken in handling this problem is to specify exactly the section that is desired and then insist that it be built that way. This will foster the designing of machinery that will build this section. Whether the dipper dredge and dragline machine can be improved to do this or whether some sort of a template excavator must be invented that will move cheaply all kinds of earth remains to be seen. At any rate, a change must be made or we will continue making open ditches that are a continual expense to maintain and never permanent. Instead of designing ditches that the present machinery can build we should try to develop machinery that can build the ditch that will stand.

HINTS ON THE CONSTRUCTION OF VITRIFIED CLAY SEGMENT BLOCK SEWERS.*

AT the present time, there are on the market two vitrified sewer blocks of different design, one being a single-ring block and the other a two-ring block. The single block has a ship-lap joint on the ends and a tongue and groove joint on the sides, while in the double block, the laps and joints are made in the construction of the sewer and the blocks are placed one on top of the other as in a two-ring brick sewer. The blocks are hollow longitudinally with web braces. They are made for sewers varying in size from 30 to 108 ins. in diameter, and according to size, weigh from 40 up to 120 lbs., are 18 and 24 ins. long, are from 9 to 15 ins. wide, and are from 5 to 10 ins. thick. Short lengths are also made for convenience in construction and for use on sharp curves. Special blocks are also made for connections and junctions and consequently this type of sewer is as flexible as any pipe, brick, or concrete sewer. The blocks are also made for use in egg-shaped sewers, in which case, an extra heavy base block is furnished.

In constructing the sewer with the blocks, the method of excavating the trench does not vary from methods used in constructing sewers of other types. If the soil excavated is stiff enough to permit, the bottom of the trench should be shaped to conform to the outside of the sewer, thus forming a good foundation and eliminating excessive tamping. A template may be used to procure this shape as well as a means of guidance for laying the blocks. The first block is laid in the centre of the trench to line and grade and the blocks comprising the invert are laid to it. As the blocks of the invert are laid up, care in back-filling behind the blocks must be practised. The joints, both end and side, must be mortared about ¼ in. thick, and the blocks must be laid broken or staggered. The joints of the invert may be pointed up as they are laid. Careful tamping on each side of the spring line behind the blocks will give much added strength to the sewer and this tamping should continue to the second course above the spring line. Wooden forms are used for the arch and are usually placed a little bit higher than the required diameter in order to allow a little wider space for the key block. The blocks are then laid up on either side of the form, the key block finally inserted, the form immediately removed, and the arch will then settle into place and form the correct diameter. Backfilling can then be started at once. In laying these blocks, experienced bricklayers are not needed, as the ordinary pipelayer can soon pick up the art of laying the blocks. If wet and quicksandy conditions prevail in the trench and sheeting is necessary, it must be driven low and cut off and left in the trench below the spring line. In cases where steel sheeting would be used, very careful backfilling must be resorted to and as the sheeting is slowly pulled, water flushing must be carried on as it is very necessary that a good bearing be given the invert. In cases where the soil conditions in the trench bottom are very bad, planks may be laid under the first block or a cradle may be used for holding the first few blocks. However, there are no disadvantages in using the block in bad trench work not encountered in using other materials, and it is claimed by some of the engineers that have used them in bad trench conditions, that they are to be preferred to any other type of material.

The cost of laying the blocks, of course, varies with the efficiency of the contractor and his organization, and with the varying labor conditions. It should not exceed 1 cent per inch in diameter of the sewer per lineal foot; this to include labor of laying, cost of mortar, and backfilling up to the spring line. The cost of the block is moderate and has the advantage over the large sewer pipe in that it takes a smaller freight rate, the breakage in transit is exceedingly small, and the cost of handling from cars to trench and in the trench is low as it is easily a one-man job. The cost of the block sewer complete is undoubtedly lower than the cost of either the brick or reinforced concrete sewer, and on account of its lower coefficient of friction, smaller sewers may be used with as good results as larger sizes of the other two materials with a consequent lowering of cost. There is only 7 per cent. of surface exposed to the jointing material in the block sewer as against 28 per cent. in the brick sewer, and the highly glazed impervious block is certainly superior to the ordinary sewer brick. Good speed in construction can be made and it is not necessary to have much trench open ahead of the block-laying and, as mentioned before, backfilling can be done as soon as forms are lowered and the work cleaned up generally as it progresses. All of these points tend to lower the cost of this type of sewer with the advantage of giving a more efficient structure.

Good connections can be made between segment block sewers of different size as well as between segment block sewers and pipe lines. The segment block sewer can also be adjusted to fit sharp curves with very little loss of efficiency. Special blocks are made for the small connections with the pipe molded to the block and in the large sizes, four or six adjacent blocks are so molded in the manufacture to permit of the entrance of the large pipe and thus saves any cutting or chipping of the block on the construction work. The matter of sub-drainage is eliminated, as the ducts in the hollow block form a subdrain and the ground water is readily carried off.

These blocks, while being particularly adapted for use in constructing storm and sanitary sewers, are also coming into use as outlet drains for large farm drainage projects instead of small open ditches. They can also be used for service tunnels as well as for highway culverts. Sewers of vitrified clay segment blocks have been constructed during the past few years in many cities in this country and Canada.

Both internal hydrostatic pressure and loading tests have been carried on in connection with this type of sewer and the results of these tests may be obtained from the manufacturers and testing laboratories, it being enough to state here that the strength of the blocks have proven ample and sufficient for the use for which they are made. Examinations of segment block sewers have been made after they have been in use for some time and the reports are that they are in good shape and answering their purpose in every respect. Perhaps one of the most critical tests in actual practice was made at Louisville, Kentucky, where a 72-in. diameter block sewer was examined after it had been in service for two years, being located in a trench 28 ft. deep. The examination showed that the sewer was in perfect condition with absolutely no defects either from abrasion or the weight of the fill above the same.

*From a paper read before the annual meeting of Illinois Society of Engineers and Surveyors, by J. M. Egan, Jr.

The asphalt deposits found at Trinidad and the Red Sea are practically pure bitumen.

Owing to the scarcity of box cars for shipping automobiles, an American manufacturer is using flat cars and gondolas. After loading the cars on board, a heavy tarpaulin is used to cover them, something similar to the English method.

WATER SUPPLY OF THE CITY OF ST. JOHN, N.B.

By R. FRASER ARMSTRONG, A.M.Can.Soc.C.E.,
Engineer and Superintendent Water and Sewage Department

THE city of St. John, owing to geographical conditions, is provided with two separate water supply systems. The city is situated on the Bay of Fundy at the mouth of the St. John River, which divides it into two parts, the city proper being on the eastern and the other part being on the western peninsula.

The eastern side was supplied with water by a company which was organized in 1836.

On the advice of a noted American engineer, Colonel Baldwin, a small body of water called Lily Lake, in the northeastern part of the city, was chosen as a source of supply. The area is 27 acres and elevation above city high-water datum is 80 feet. Construction commenced in 1837 and the supply was available to the city in October, 1838.

The works, as then constructed, consisted of a small wooden-box conduit which conveyed the water by gravity from the outlet of Lily Lake to a steam pump, which forced the water through 10 and 12-inch cast iron pipes to the distribution reservoir. The supply was of an intermittent character, the water being pumped to the reservoir three or four times a week, and doled out daily to the consumers between the hours of 6 and 8 a.m. and a sufficient supply had to be drawn during the two hours that the water was on to last the balance of the day. When a fire occurred no water was available at any hydrant until the water was let on from the reservoir and the mains filled.

Fig. 1.—Concrete Dam at Lake Robertson.

The system was not long in operation, however, until it was discovered that, aside from the unsatisfactory service, the water was not well suited for domestic or steam purposes; and the obtainable supply altogether inadequate for the future requirements of the city. These most undesirable conditions led to an investigation being carried on to obtain not only a more potable and copious supply but also a more satisfactory service. The first survey made with a view to a change was conducted by R. C. Minnette, Esq., C.E., then city surveyor. It was found that good water could be obtained at Little River at a point about 4½ miles from the city in an easterly direction, at what was then considered sufficient elevation to supply the greater part of the city by gravity for some years to come. Chas. W. Fairbanks, civil engineer, of Halifax, was then employed to investigate and report upon the proposed works. Mr. Fairbanks chose a site for a reservoir on Little River, recommended the erection of a dam and the placing of a 12-inch cast iron pipe from this point to the city. Construction work was undertaken by the company in October, 1850, and in September, 1851, the water was formally turned on to the city from this new source.

The bed of the river at the point selected for the reservoir is 140 ft. above city high-water datum, the reservoir, as at first constructed, having a surface area of about 37 acres, with a drainage area of about 9,500 acres.

The distribution reservoir was now fed by gravity, but it was found in cold weather, when the consumption on the lower levels was high, that the consequent increase of friction in mains caused pressure to drop to such an extent that water would not flow up the Carmarthen St. hill. This very evident lack of pressure and the cholera epidemic of 1854 aroused the citizens to the necessity of a more abundant and potable supply of water which would be, in a measure, under the control of the city.

The outcome of this was that under an Act of Assembly, commissioners of water and sewerage for the city of St. John (East) and a part of the parish of Portland, were appointed.

The duties of the commissioners were to take over, construct and maintain the sewers and all works for the supply of water to that part of the city of St. John lying on the eastern side of the harbor and the water supply works of the urban portion of the adjoining parish of Portland.

Several improvements in the inside distribution were immediately undertaken, but the commissioners soon realized that their system was inadequate for future requirements, so, on the recommendation of the superintendent, which was confirmed by James Slade, Esq., then city engineer of Boston, it was decided to place a 24-inch cast iron pipe main from Marsh Bridge to Little River, the idea being that eventually this pipe would be extended to Lake Douglas or to some source capable of adequately supplying the city's requirements. The 24-inch supply main was completed in 1857 and in the same year observations were taken to determine the capacity of Lake Latimer, where an additional head of about 150 ft. could be obtained. These observations satisfied the commissioners that this lake could only be used for compensation purposes or in conjunction with some larger supply scheme.

The city was now supplied from Little River by the two cast iron mains, the 24-inch and the old 12-inch.

By the placing of the new supply main the service was much improved, but as the inside distribution was extended and consumption gradually increased, it was not long before the friction losses demanded that additional supply mains be considered.

With a view to increasing pressure and also to duplicating the large pipe running into the city, so that in case of accident to one pipe the city would not be wholly without water, it was decided to place another 24-inch supply main, which work was completed in 1874.

The Little River reservoir, assisted at times by Lake Latimer, while apparently being capable of furnishing an abundant supply, was not at a sufficiently high elevation to supply water to the summits of the city. The inconveniences arising from this low elevation of supply head were aggravated during the winter by water being too freely used in the lower levels, to keep services from freezing. The number of consumers kept increasing from year to year and such unwarranted quantities of water were wasted that each year marked a decrease in the pressure head through the entire city. This lack of pressure demanded that either a pumping plant be installed or that the supply mains be continued to some other source of sufficient elevation to assure adequate pressure over the entire city.

For a time a portion of the distribution on the higher levels was isolated and a water turbine-driven pump installed at Silver Falls. Within certain limits this pump was satisfactory, but its capacity was too small to allow for fire or any large demand and at these times it "raced." This condition might have been relieved by having it always pump against a definite head.

When the question of a gravity supply first came up it was recognized that Loch Lomond would be the ultimate source of supply, as the elevation, volume, softness and purities of the waters presented strong arguments in its favor and when the scheme of supply from Little River was adopted, it was realized that this was only a unit of a future larger scheme. The drainage area of the Little River basin is about 9,500 acres or about one-third the drainage of Loch Lomond.

In the year 1882 Gilbert Murdoch presented a very comprehensive report to the commissioners, discussing at considerable length the proposed schemes for improving the water supply at that time. Mr. Murdoch practically accepted Loch Lomond as the ultimate source, his report being a consideration of the several routes of reaching this lake. The routes considered were: (1) By way of Lake Douglas; (2) by way of Lake Donaldson; (3) by way of Lake Latimer. In summing up, Mr. Murdoch expressed the opinion that the Lake Latimer route was the superior one and this route was ultimately adopted.

Loch Lomond is situated about 10½ miles from the city in approximately the same direction as Little River reservoir. Surface elevation about 300 feet above city high-water datum, and area of Lower, Middle and Upper Loch Lomonds, which are all connected, about 2,480 acres. This may be further increased by converting the principal feeders (Lakes Otter, Terrio, Godsoe and Chambers) into storage reservoirs, as could easily be done were such required.

The drainage area comprises about 27,700 acres. The water is soft and of a very superior quality.

Lake Latimer is situated about 7⅓ miles from the city in a line with the Little River supply, has a surface area of about 210 acres, great depth, and an elevation about 300 feet above city high-water datum. The drainage area is only about 550 acres, much of its water originating from springs and the capacity of the lake is not sufficient to supply the requirements of the city.

Lake Douglas is between Little River reservoir and Loch Lomond, being almost directly north of Lake Latimer.

Lake Donaldson is between Lake Latimer and Loch Lomond, being northwest of the present concrete dam across the Mispec River, the outlet of Loch Lomond.

As the demand for a better service on the higher levels became more insistent, Snow and Barbour, consulting engineers of Boston, were called in to make a report. In general, their report was a confirmation of reports that William Murdoch had made in previous years. The recommendations as given by Snow and Barbour were adopted and they were authorized to prepare plans and specifications for a water supply extension.

In 1905 these plans and specifications were accepted, tenders for construction awarded and water has been used from this source since 1906.

A concrete dam was built across the Mispec River, the outlet of Loch Lomond, backing the water up and forming what is now known as Lake Robertson. From the dam a 48-inch horse-shoe shaped reinforced concrete conduit extends a distance of 6,916 feet and empties into Lake Latimer, keeping Lake Latimer at approximately the normal level of 298 feet above city high-water datum. A 39-inch horse-shoe shaped reinforced concrete conduit conveys the water from Lake Latimer to an open chamber at Finney's Hill, a distance of 7,480 feet. The level of water in this chamber is the head from which computations for pressures in the city are made. From this point the elevation of the ground drops rather abruptly and the water is carried through a 33-inch diameter wood-stave pipe, a distance of 9,880 feet, and the wood-stave pipe is connected at the Little River gate-house through 400 feet of 36-inch cast iron pipe with the three cast iron supply mains leading into the city, a distance of 23,000 feet.

The total value of waterworks of the city is nearly two and a half million dollars. This includes the two supplies.

THE CREOSOTE INDUSTRY.

During the past year, according to the Victoria, B.C., Daily Colonist, a shipment of 160,000 creosoted railway ties was made by the Dominion Creosote Company of Vancouver, to India, for the Bengal and Northwestern Railway Company. The Indian railways use annually large quantities of sleepers which have been supplied from Australia, but as Australian timber is becoming scarcer and prices are advancing, it is expected that the British Columbia product will come into more demand.

Although the preservative treatment of wood industry in British Columbia was established only five years ago, it has had a steady growth, particularly in export markets. At present only one plant is in operation, that of the Dominion Creosote Co., but a second is about to be established. The former covers twenty-two acres on the north arm of the Fraser River with river frontage of 1,300 feet. The company operates a sawmill with daily production of 55,000 to 60,000 feet per ten hours; a paving block mill with capacity of 1,600 yards of block paving a day and a creosoting plant with two retorts one hundred feet long.

The projected plant is that of the Vancouver Creosoting Co. This company has secured a site with five hundred feet of waterfront at North Vancouver, and expects to build a plant at a cost of $150,000 by April next.

Including the Dominion Creosote Co., there are four producing plants in Canada, the others being the Dominion Tar and Chemical Co., of Sydney and Winnipeg; the Canada Creosoting Co., Trenton, and Alex. Bruce & Co., Fort Frances.

THE ENGINEER AND THE WAR.*

By Walter J. Francis, C.E.,
Consulting Engineer, Montreal.

It is the engineer who harnesses the Niagaras of the world to transform the night of our cities into noonday and to turn the wheels of commerce.

It is the engineer who develops the mining and furnishes the metal with which he builds machines that, by their ingenuity, compel us to stand in awe and admiration.

It is the engineer who produces the steel to form a network of highways over our continents, and that makes possible the myriads of floating palaces on our oceans.

It is the engineer who has abolished famine and pestilence.

It is the engineer who has annihilated distance with his telegraph and his telephone.

It is the engineer who has made possible the conquest of the air.

It is the engineer who furnishes the worker in the golden west with the machines whereby millions of bushels of wheat are each year made ready to enter the hopper that the engineer has constructed.

It is the engineer who has made the Canada of to-day what she is.

Imagine, if you can, the cessation of all engineering activities, the obliteration of the living engineers and the death of engineering instinct, and our much-vaunted present-day civilization is immediately plunged into the darkness of the middle ages. In a century, engineering spans the chasm between the messenger on horseback or the beacon lights on the elevated places and the wireless telegraph service, the chasm between the ox-cart or the caravan and the palatial Pullman trains, the chasm between the wooden sailing vessel and the luxurious floating palaces, the chasm between the powder-horn and flintlock and the modern machine gun, the chasm between the most primitive manual labor and the most highly organized mechanical processes. The steel industry, the flying machine and the under-water boat are all engineering creations, and so modern in their conception that it seems impossible to name any connecting link with the past—they are new.

Who was the first engineer? I have a notion that the first engineer was probably that simian who discovered that the use of a stick enabled him to more readily knock down the cocoanuts than by laboriously climbing the tree. His object was to knock down cocoanuts. The simians that gathered them up were doubtless the first financiers. Of course, they encouraged the engineer, and the engineer developed his apparatus for the purpose of increasing the output. We have kept on in the development—and the others have kept on with the gathering in. The development has become so natural and so universal that we have grown as unmindful of it as of fine weather and good health and all the other blessings of heaven.

From time immemorial, engineers have come forward in times of war and have rendered signal service. Xerxes sent his armies across the Dardanelles into Europe over a bridge of boats. Darius cut a canal at the site of the present Suez Canal to prevent the passage of the enemy horde. The military roads of the Romans are still wonders of the constructive art. The stone cannon balls and the "frightful noise" of the guns of the middle ages are well worth reading about. The fortresses over Europe have withstood every attack until the advent of present-day artillery. Naval supremacy has been obtained by engineering development.

Doubtless the earliest application of modern engineering to the problems of warfare is to be found in the case of Khartum, where the foremost of Royal Engineers raised the Union Jack in 1898. Kitchener, of Khartum, combined all the qualities of the soldier, the organizer and the engineer. Appreciating the futility of hurling his soldiers into the desert melting-pot, he decided to build the world-famous military instrument—the Sudan Military Railway, whereby he was able to transport not only the troops, but also everything for their needs. In this he was ably assisted by Bimbashi Girouard—a Canadian, a graduate of the Royal Military College, and one of the engineers on the construction of the C.P.R., of whom Steevens had said: "Girouard goes on building and running his railways—over five hundred miles of rails laid in a savage desert, a record to make the reputation of any engineer in the world."

In the next war engineering played no less a part. To South Africa went Kitchener, and with Kitchener the solution of all the difficulties of transportation problems. Here the crafty guerilla warfare of those "peaceful, pastoral people," the Boers, made serious havoc with the railways. Embankments were destroyed, culverts blown up and bridges torn down. A most complete military organization was built up to cover the territory by the Royal Engineers. The Imperial Military Railway became a great institution with Girouard again at the head. Included on the staff, in positions of great importance, were Colonel H. S. Greenwood and Mr. A. F. Stewart, both of the C.N.R., and well known to many Canadians. The Royal Engineers did the whole work thoroughly, without overlapping or loss of time. To mention just one incident recounted in the official report, "on one occasion (January 1st, 1901), information of a break near Wolvehock reached Major Lindsay at Kroonstad at 2.30 a.m. The distance to the break was 63 miles. Nevertheless, this distance had been traversed and the break repaired by 8 a.m." In order to get a proper estimate of the work of the field engineers it is essential to remember that they are armed soldiers, frequently carrying on their work under enemy fire.

The Right Honorable David Lloyd George, the Minister of Munitions, in a speech delivered last summer, is reported to have said that the present war is a terrific contest between the engineers of the warring nations. The object lesson so tragically taught by Germany has aroused the other nations of the world to a keen appreciation of the result of the application of engineering energy to military purposes. While Germany was, as we all think, so misapplying a great part of her engineering talent, the other nations had been devoting their efforts to the development of the arts of peace. We have been forced to meet the exigencies of the situation, and to our military engineers and to the engineers in civil life has fallen the task of overtaking Germany's forty years of preparation, not only on the fields of battle, but in the workshops at home. Two of the most eminent military engineers of the world are in foremost places—Lord Kitchener and General Joffre.

*Abstract of an address before the Ottawa Branch of the Canadian Society of Civil Engineers.

The war is an immense work of cold, calculated programme. Let us draw an analogy. A building contractor, let us say, determines to carry out a piece of work in a certain time. He calls his superintendent and explains what is to be done and when it is to be finished. The superintendent, in turn, calls his foreman and the various interests to whom he looks for co-operation and assistance. The materials are ordered. The laborers and artisans start their work—and the work is completed according to the wishes of the master mind. It is all a matter of mature forethought and cold calculation. There is nothing of accident or haphazard trust-to-luck haste. It is all carefully thought out ahead. The proceedings in the war are quite analagous, only on a stupendous scale. Nothing happens by chance. The constant care is to be in readiness at the necessary or appointed time. I would not modify my analogy, but would point out that Germany stands in the position of a contractor with an organization complete and ready, while the Allies have to be likened to one who may be without an organization and have to build it up. King Albert, the Belgian engineers, the engineers of France, and the British Navy were partly prepared, or we should not have the privilege of discussing the subject this evening.

There was one at least of the Canadian engineers who specially prepared himself in his spare hours for the service of his country in time of need. The reference is to Lt.-Colonel Charles H. Mitchell, General Staff Officer in charge of the Intelligence Department of the Canadian Army Corps in France. In a card recently received from him, he says:—

"The nice feature about my work is that after all it's pretty much the same in its type as consulting engineering—in fact, is the same if you substitute the Huns for the forces of nature." And in a letter just received, he says:—

"It is strange, and yet very fortunate, what an analogy there is between this work and my own professional work at home. The general character of the work, life and thought is similar, the assistants similar and one's activities are quite the same—office work, reports, analysis, correspondence, direction of investigations, deductions, maps, outside tours of inspection, constant telephone activity—all the same if you substitute the enemy for the forces of nature. There is a difference, though. It is seven days a week from 9 a.m. until 11 p.m. Our headquarters are in the Hotel De Ville of this little city (about 12,000 people normally), and it is really quiet and peaceful if one gets used to the passing to and fro of thousands of men and hundreds of motor lorries, motor cars, wagons, and so on, in the day, and the recent aeroplane activity by the enemy, in which he has been dropping bombs on various parts of the town, railway station, flying aerodrome locality, and not forgetting the cemetery. I had the misfortune last Sunday to lose one of my best draftsmen, killed on the street on his way to a noonday meal."

Canada is to be congratulated on the special services required of her soldiers. Like Sir Percival Girouard, Colonel Ramsay, of the C.P.R., has been called to the front with a corps of railway constructors, every man a specialist in a particular branch of railway construction. He has since been followed by a second corps, and now other engineering parties are being called for to render special services at the front. One of the most unique of these parties is one armed with broadaxes, and recently inspected by His Royal Highness in this city. In Flanders we can see them performing their task fearlessly and faithfully. Under the fire of the enemy they unflinchingly construct their bridges and prepare their highways. With tireless energy they minister to the needs and convenience of the men in the trenches. Anywhere, everywhere, their services are required, and the special skill stands them in good stead, for it must be remembered that in these bodies of men are artisans of all classes. Among the classes required by an engineer corps are bricklayers, carpenters, draftsmen, mechanics, masons, wheelwrights, shoemakers, clerks, drivers, chauffeurs, saddlers, plumbers and tailors.

The Canadian Society of Civil Engineers has nearly five hundred of its members on the field of honor, and some have made the supreme sacrifice. The whole of the struggle is not on the battle-fields, nor, indeed, in Europe. Soldiers must not be without ammunition. At the outbreak of the war nobody in Canada knew how to make ammunition on a commercial scale. Metal manufacturing industries were paralyzed by the interruption of normal conditions. The Allies needed shells. The Canadian manufacturers in a body rose to the occasion and transformed the shops of the Dominion into shell factories. The speed with which this transformation was accomplished probably stands without a parallel in the history of manufacturing. The Government appointed as the head of a commission an engineer whose knowledge of the machine shops of Canada had been gained from a lifetime in the work, following his father, and in a few months the shops of Canada had learned their lesson and were exporting shells to the Allies. In recognition of his services Alexander Bertram was knighted by His Majesty King George at the New Year.

The celerity with which new methods, new processes and accurate measurements were put into practice is a standing monument to the skill of Canadian manufacturing engineers. To illustrate, by a few figures, the transformation which has taken place in one shop alone. Prior to the war this engineering firm employed about twelve hundred men and had a daily output valued at about $30,000. To-day, the employees number five thousand men and the value of the daily output is $200,000. It is a significant fact that the president of the Canadian Society of Civil Engineers, as well as two of the immediate past-presidents, are all, directly or indirectly, engaged in the manufacture of ammunition.

Naturally, from the present conditions in Canada we pass to the thought of the future. When the war is over and when German militarism will have been crushed, what of Canada? Already a new word has been coined in the United States, "preparedness." President Wilson recently said: "There may come a time when I cannot preserve both the honor and the peace of the United States," and the outcome of this movement has been the appointment of a consulting board of specially chosen engineers, composed principally of the representatives from the five foremost engineering institutions of the United States, the American Society of Civil Engineers, the American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers and the American Chemical Society. Its immediate work will be to make an inventory of the facts necessary to be known to the army and navy relating to the resources of the nation for the supply of munitions of war in case of need. The French Republic has organized a similar civilian board, and has raised it to the dignity of a ministry, "Le Ministere des Inven-

tions." Great Britain has also enlisted the services of civilian scientists and technologists with a view to the development to the utmost of the nation's industries for the prosecution of the war.

Meanwhile the world struggle is becoming fiercer. The engineers in civil life must attend to the production and the transportation. The mines must be kept producing the raw materials and the factories the finished products. The railways and the steamships and the motor cars must take them to the front, where the military engineers, amidst the inferno of shell and machine gun fire, are doing their part under the old motto of the Royal Engineers, "Everywhere," and continuing the fight, led by the stirring war-cry, "Where right and glory lead."

CIVIL SERVICE COMMISSION OF CANADA.

The Civil Service Commission of Canada announces that applications will be received for the following position in the Inside Division of the Civil Service Commission of Canada:—

A technical clerk in the Railway Land Branch of the Division of the Interior, Sub-Division B of the Second Division. The salary is $1,300 a year. Candidates must be able to compile and check plans, be experienced in preparing descriptions of lands, and able to conduct technical correspondence relating to these subjects. Candidates should have had at least five years' experience in work of this or similar nature or be graduates in science of a recognized University, Applications are to be in by the 17th of April next, and application forms may be obtained from Wm. Foran, Secretary of the Commission, Ottawa.

STRENGTH OF SLAG CONCRETE.

A series of very interesting and important tests has recently been made at Columbia University, in New York, in which concrete made from blast furnace slag showed over 18 per cent. greater resistance to compression than concrete made of trap rock from the Palisades. The slag used was recovered from the large slag dumps of the Bethlehem Steel Company at South Bethlehem, Pa., and marketed by the National Slag Company, Newark, N.J., which has a reclaiming and crushing plant at South Bethlehem. The tests were conducted for the building departments of New York and Newark, the Public Service Commission of the First District of New York, the Public Utility Commission of New Jersey and the Erie Railroad. Four tests were made in each case of 8 x 16-in. cylinders of concrete of 28 days, 3 months, 6 months and 12 months' age, the concrete made of sand from the same source and in the same way. A 1:2:4 mixture was used. The National slag concrete of the 28-day period averaged 2,465 lb. per square inch compressive strength, which was 24.8 per cent. higher than the trap-rock concrete. The slag concrete of 3 months showed 3,496 lb. compressive strength, or 18 per cent. better than the rock concrete; for 6 months the strength was 3,567 lb., and 16.9 per cent. better than the rock concrete, and for 12 months, the strength was 4,187 lb., against 3,547 lb. for the rock concrete, or 18.4 per cent. better. National slag weighs 80 lb. per cubic foot and Palisade trap rock 100 lb.; the concrete with the slag weighs 140 lb. per cubic foot, and that with the rock weighs 151 lb. per cubic foot.

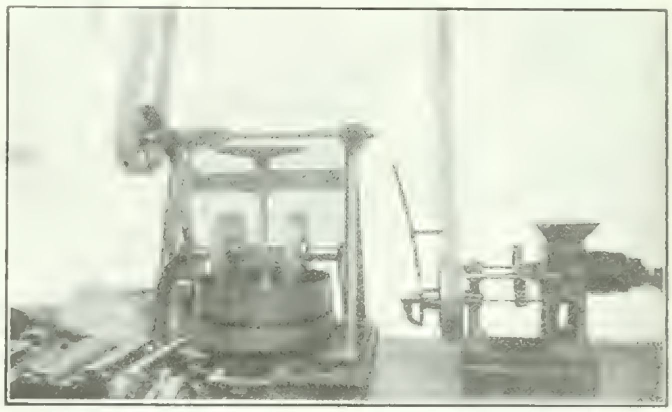
NEW LABORATORIES AT OTTAWA.

TWO new laboratories of special interest to engineers have been installed by the Mines Branch at Ottawa, descriptions of which have been given in recent reports of the Mines Branch. One of these, the ceramics laboratory, owes its existence to the great development of commercial activities prior to the war, which necessitated its establishment to investigate Canada's resources in this line.

The commercial value of clay products in Canada may be estimated from the following figures, collected through the statistical division of the Mines Branch. The clay products mentioned were manufactured in Canada during the years 1912 to 1914.

	— Production in —		
	1912.	1913.	1914.
Brick, common	$ 7,010,375	$5,917,373	$3,653,861
" pressed	1,609,854	1,458,733	1,115,556
" paving	85,989	75,669	49,627
" ornamental..	8,595	15,423	23,592
Fire-clay and fire-clay products	125,585	142,738	107,568
Fireproofing	448,853	461,387	405,543
Pottery	43,955	53,533	35,371
Sewer pipe	884,641	1,035,906	1,104,499
Tiles	357,862	338,552	366,340
Kaolin	160	5,000	10,000
Total value	$10,575,869	$9,504,314	$6,871,957

During the year 1905 the importation of clay products amounted in value to $2,501,206, and it increased

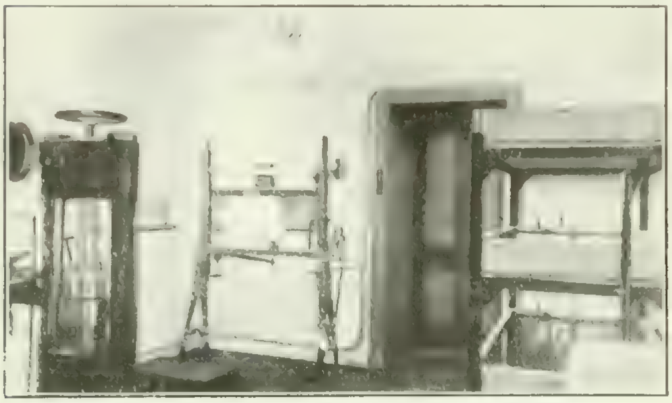


Ceramic Laboratory—Dry Grinding Pan and Experimental Auger Machine.

to $6,760,762 for the year 1913, but dropped in 1914 to $4,467,140, due to the war. In the year 1914, we utilized clay products valued at $11,291,024, yet the returns show that we imported over 39 per cent. of these products. This simple statement shows that in 1914 we sent out of Canada for these products alone, $4,419,067 which if it had been held in our own country, would have meant the investment of a large amount of capital, and would have given employment to a large number of men.

It must not be concluded from this statement that this very large importation is due to lack of raw materials at home. Reports on the location and character of the clay deposits of Manitoba, Saskatchewan, Alberta, Quebec, and the Maritime Provinces, issued by the Geological Survey, show that Canada is rich in materials for an important ceramic industry. New deposits are constantly being discovered and specimens sent to the laboratories,

with the request that they state what use can be made of the material. To merely send the owner of the deposit a chemical analysis of his clay does not meet the case, since chemical analysis is only a preliminary step in ascertaining the fitness or unfitness of a clay for the manufacture of any special product. Before a sound opinion can be arrived at, as to whether a particular specimen of clay is suitable for the manufacture of tiles, brick, terra cotta,



Structural Materials Laboratory, Showing Compression and Tension Machines.

sewer pipe, or other clay products, the specimen must be submitted to a physical examination to ascertain the character of the product as it comes from the kiln. It is during this investigation that the problem, in many cases, admits of solution, namely, how a clay, otherwise unfit, may, by special treatment, be rendered suitable for the manufacture of a commercial product. To enable the government to furnish this complete information regarding clays submitted by prospective operators of clay deposits, provision was made for the establishment of a ceramic division in the Mines Branch, with a properly trained and experienced ceramic specialist in charge. The completion and equipment of the ceramic laboratory was accomplished during the latter part of 1915. Through the activities of this Division, intelligent assistance will be given to the manufacturers of clay products. It is ex-

Ceramic Laboratory—Kiln Room, Showing Cement and Brick Kilns.

pected that this course will lead, on the one hand, to a decrease in the large imports of clay products, and on the other hand, tend to the further development and increasing importance of the ceramic industry in the Dominion.

Another laboratory, that for testing structural materials, was equipped with apparatus which would make a more thorough study of materials possible than had been heretofore, as a physical test had been the only means of examination.

In equipping this laboratory, adequate provision was made for conducting complete tests on all kinds of building supplies, etc., such as sands, brick, stones, cement, concrete, and like materials. The laboratory equipment includes machines for making all the physical tests necessary for the determination of the transverse, tensile, and compression strength of all structural materials. The installation of the machines for testing iron and steel is complete.

The increasing use of bituminous materials in the surfacing of city streets and interurban highways, has emphasized the necessity for apparatus suitable for the testing of such materials; but in connection with the installation of apparatus for the examination of bituminous road materials—including bituminous sand—there has been a regrettable absence of generally accepted standard methods of testing. The apparatus available in the Mines Branch Structural Materials Testing Laboratory, however, is well suited for classifying, and for determining the value of bituminous road materials.

THE ERIE RAILROAD LIBRARY.

The Erie Railroad has opened at its general office in New York City a free circulating and reference library for the use of the 1,300 persons employed in the offices of the company in that building and nearby. On the day that the library was opened, March 14th, the shelves were almost swept clear of the several hundred volumes which had been provided, and a "rush order" was sent out for more books. The demand was keen from all classes of employees, from girls who count tickets in the auditing department up to the higher officers.

The library, which is described in Railway Age Gazette, consists of standard text books and reference works, engineering and technical books of interest to railroad men, and also the latest popular fiction, together with current periodicals and newspapers. Employees in all departments will here find facilities to educate themselves in their own work, and also to inform themselves concerning other departments of the railway service. The library contains about 1,000 books.

The demand for steel from domestic consumers is increasing instead of falling off and Europe is in the market for almost unheard of tonnages for shell purposes and for railway steel. There is no doubt in the minds of manufacturers that prices will go higher than ever seen before.

The busiest street intersection in the world is in New York City at Fifth Ave. and 42nd St., according to a recent count by the Traffic Committee of the Fifth Avenue Association. According to this investigation, between 3.30 and 4.30 p.m. on the day of the test, 1,149 vehicles were counted proceeding south. J. Bernstein, who made the count for the committee, stated that the top figure for the Strand, London, is 900 vehicles per hour, and in Paris the record is 600 in an hour on the Boulevard des Capucines. The count revealed other interesting statistics: Of the vehicles on Fifth Ave. at 42nd St. 92 per cent. are now motor-driven. Between 8.30 a.m. and 6.30 p.m., under unfavorable weather conditions, 7,762 passenger vehicles were counted northbound, of which 300 were commercial (of these 60 per cent. were horse-drawn), while 600 busses passed in the 10 hours. The grand total was 8,862. The traffic peak was between 2.30 and 3.30 p.m. Southbound in the avenue the total for the day was 7,[illegible] consisting of [illegible],388 passenger vehicles, 198 commercial and [illegible]4 busses. On 42nd St. the total from east to west was 4,716; and from west to east, 3,909.

BITUMINOUS ROADS.*

By Robt. C. Muir, A.M.Can.Soc.C.E.

BITUMINOUS roads constitute a modern development to meet both the actual needs under modern traffic and the desires of modern civilization for greater efficiency, comfort, satisfaction and better sanitary conditions.

The introduction of the motor vehicle has greatly changed the conditions under which a road exists. The suction action of yielding tires is to remove the binder in a macadam surface and thus expose the stone to the action of traffic and the weather. There is then no longer a solid mass to meet conditions and disintegration occurs. Therefore, it is necessary to protect the macadam surface against this action of high-speed vehicles. Of the various materials which have been used in several types of roads, there is none equal to bitumen in its ability to withstand water, abrasion, and temperature changes.

There are three ways in which a road may be treated with bitumen, namely: (1) Penetration method, known as bituminous macadam; (2) mixing method, known as bituminous concrete; (3) bituminous surface, known as carpet coat.

A choice of these methods depends upon conditions, traffic conditions being the chief factor in deciding which of the three methods should be adopted.

Foundation and Drainage.—The necessity for stronger foundations and to this end for the best possible subdrainage, seems to be generally accepted, especially by those whose vision into the future is keen enough to permit them to recognize the probable increase in demands on the foundations, to be brought about by better surfaces and by the consequent growth in both the bulk and weight of traffic as well as in its severity. A firm foundation is an essential factor for permanent bituminous surfaces.

Again, in bituminous macadam the binding action of the bitumen tends to make the top course "spring" after each passing of the roller and in that way the road never can become firm with a yielding bottom course or foundation.

Bituminous Macadam (penetration method of construction).—On the prepared foundation, a layer of clean stone, varying in size from 1½ ins. to 2 ins. or 2 ins. to 3 ins., should be spread to an uniform depth, usually 4 ins., loose measurement. This is then rolled only until the stones have keyed together. On this surface prepared bituminous material heated to about 375° F., is applied at the rate of 1¾ gallons per square yard. Following this application stone chips are spread on the surface to fill the voids, and in sufficient quantity to cover the surface and permit the passing of the roller without adhesion of the bitumen to the wheels. This is then thoroughly rolled until the surface is uniform and hard. The squeegee or seal coat of bituminous material is then applied at the rate of ⅓ gallon per square yard, followed with an application of stone screenings from ⅛ in. to ½ in. in size, clean, dry and free from dust, sufficient to take up all excess bituminous material. The whole is then rolled, and by the aid of brooms and the adding of more screenings if necessary, a uniform hard and smooth surface results.

With this method of construction the question of size and shape of stone is supposed to be an important point. It is not so much the size as a practical uniformity in size that is essential. That is to say, if the smaller stone run about 1¼ ins. to 1½ ins., then the larger stone should not be greater than 2½ ins. On the other hand, if the smaller stone is 2 ins. in size, then the larger stone may run 3 ins. The point is that a wide variation in size of the stone causes an irregular delivery; one load may run all fine and the next load all coarse stone. This condition is detrimental to the surface of road. The best results have been obtained by the use of stone passing a 2½-in. screen and retained by a 1½-in. screen, with stones breaking cubically with fairly rough surfaces and with sharp angles.

Still another important factor affecting a bituminous road is the sufficiency of the rolling given, as also in the case of a waterbound macadam road. It is fully recognized that with waterbound macadam roads, the utmost possible compaction and interlocking of the stone by rolling is necessary for first-class results. Hence, let us all remember the saying, "Rolling is the life of the road."

The proper selection of the bituminous material for use under this method, or under any method, is a serious one and is influenced by many conditions other than method of use, such as price, soil, weather and traffic conditions, conditions likely to prevail regarding after-maintenance and cleaning.

The use of unrefined tars has been found unsatisfactory and has been practically abandoned. It is generally agreed that the presence in the tar of more than a minimum of water or ammoniacal liquor renders it undesirable for this method of use; that certain amounts of "light oils" are necessary for giving the desired fluidity in handling; that a good proportion of "heavy oil" is necessary in order that the tar may retain the longest possible life in elasticity after use, and under the effects of weather and traffic as well as for giving the body to the tar asked by this method; and that a limited amount of "free carbon" may be advisable in order to help to give body to the tar and to assist in reducing its susceptibility to changes in temperature. This "free carbon" may be either the natural fraction of the tar or it may be added foreign material, such as Portland cement or finely powdered limestone.

Some surfaces built by this method with a low carbon tar have improved as fine material was supplied by traffic.

It is acknowledged that uniformity of penetration is desirable. To this end, as well as for the sake of economy, efforts have been made to supplant the early system of hand-pouring by some mechanical distribution of the bituminous material. Some very successful machines have been devised for the purpose and it seems generally agreed that the best results under this method are secured by the use of such appliances distributing the tar under pressure.

An excess of bituminous material will give a surface which will become wavy under travel, and a similar effect is produced by material containing dirt, which does not permit enough penetration. In cases of unequal distribution, which is more likely under the hose application than in the method described, lean spots break up and go to pieces, while fat spots bunch up and form bumps. If the lower course is not filled, the hot bituminous material penetrates too far, with consequent loss of material in the surface.

Cost.—The usual variations in cost, resulting from different local conditions, have been present with penetration as with any other method.

However, it may be stated that with labor and material at average prices and work within reasonable distance from railway station, the cost for constructing a bituminous macadam road, in manner described, would be about 35 cents per square yard over and above the cost of building a waterbound macadam road. A decrease in

*Read before the Conference on Road Construction, Department of Highways, Ontario, 1916.

this cost may be looked for as proficiency in practice and as mechanical appliances for the work are developed.

Bituminous Concrete (mixing method).—This type of construction has caused a great many disputes owing to the fact that there is a certain patent covering the use of stone and bitumen mixtures under certain specification. However, it has been pretty well established that if the maximum size of stone is not any greater than ½-in., and furthermore, if less than 10 per cent. is retained at ¼-in. screen, regardless of the method of grading of mineral aggregate which will give the densest mixture there is no infringement of the above-mentioned patents.

This method of construction is well adapted to the improvement of an old macadam road where it is desired to introduce a better pavement at a minimum expense under moderately heavy traffic conditions. It is more expensive than the penetration method, but is more certain in its results, and more suitable for heavy traffic. This method involves a considerable expense for machinery, namely, heating and mixing plant, and with its first cost, as before stated, has led to the development of the penetration method.

Construction.—The mineral material composing the wearing surface is mixed with a sufficient quantity of bituminous material, approximately 15 gallons of tar to 1 cubic yard of material (stone). This mixing is usually done at a plant off the roadway itself and even some distance from the road, though it is preferred that mixing be done on the work.

One of the most common mixing and heating outfits is the Link-Belt portable plant. This machine is 27 ft. long and weighs about 17 tons. Practically all of the mechanism is housed in. This plant consists of melting kettles, a dryer, a dust blower and a mixer. The material is shovelled into one end of the machine, passes through the dryer and thence into the mixer, where it is mixed with the bitumen. The power for operating the machine is obtained by belting it to a tractor or road roller. The heat for the dryer, the melting kettles, etc., is obtained by means of fire boxes underneath the machine, in which coal is burned as fuel; the hot air passing around the various parts of the machine.

The mixture should be put on the road at a temperature of not less than 220° F. The prepared foundation should receive a slight sprinkling of the bituminous material as a binder coat. On this foundation the bituminous concrete is laid and raked into place and then thoroughly rolled with a 10-ton steam roller, until no further impressions occur, to desired thickness, usually 2¼ ins. Sometimes a lighter roller is used. This surface is then given a seal or flush coat of hot bituminous material, about ¼ gallon per square yard, and covered with fine stone screenings and again rolled. In places of this flush coat the surface is sometimes dusted with a coat of Portland cement to fill any surface pores.

With this method a maximum density is sought, using stone carefully graded from fine to large. The requirements of engineers vary to a considerable extent, due to different kinds of aggregate employed; in some cases, one size crusher-run stone is used; again, combinations of broken stone and sand are used. The following specification is adopted in many places in the United States:

Passing 10-mesh sieve....	1.0 per cent.
Passing ¼-inch sieve....	5.5 per cent.
Passing ½-inch sieve....	30.8 per cent.
Passing ¾-inch sieve....	34.2 per cent.
Passing 1-inch sieve....	23.4 per cent.
Passing 1½-inch sieve....	8.1 per cent.

Cost.—The average cost per square yard for this method is about 60 cents over and above waterbound macadam.

The advantages claimed for this method (mixing) are uniformity of surface and of composition of same, maximum value of surface for materials used, economy in use of materials, maximum life of surface and economy of results.

Carpet Coat (bituminous surface).—Surface treatments may be divided into two principal classes, based upon the material used, namely, (1) Those in which tar is used; and (2) treatment with oil.

The method of surface treatment is only applicable to road surfaces already finished by other methods—usually to old or new waterbound macadam.

Two classes of tar are commonly used, one a refined coal tar with a comparatively low melting point, but not fluid at ordinary summer temperatures; the other a refined coal tar which is fluid at ordinary temperatures.

The tar surfaces have the advantage of being much cleaner than oil surfaces in wet weather. The oil surface being softer and more adhesive, holds the dirt and dust upon the surface, while the tar hardens and nothing adheres to it.

The tar road for this reason maintains a better average condition throughout the year than an oiled road. On the other hand, a tar surface is more slippery than the oil, and will, in cold weather, harden and crumble to an extent depending on the season and the kind of traffic.

The use of the first class of tar is more suited to roads of fairly heavy traffic than the second class of tar. Two coats of the latter class give about the same service as one of the first class, and at about the same cost.

The method carried out in this treatment is to clean the old surface of road to be treated free from all dirt and fine material. After such cleaning and when surface is dry, the tar is applied at a temperature of about 180° F. from a tank wagon drawn by steam roller, in a manner described in penetration method. A steam pressure of about 10 lbs. per square inch is applied to the bituminous material. This also keeps the tar hot. This surface is immediately covered with stone screenings, or preferably pea gravel, and rolled. This forms a hard crust, is firmly bound to the surface, and resists all abrasion from motor cars. Where heavily loaded, iron-tired wagons use this type of surfacing, the crust has a tendency to break up, especially in cold weather, and an annual treatment is necessary and will maintain the road in excellent condition.

The amount of tar used is usually ½ gallon per square yard.

The cost of this treatment varies from 8 cents to 14 cents per square yard; even as low as 6 cents per square yard has been recorded, including material and labor.

The advantages claimed for this method are simplicity of work, economy of first cost, and in many cases, economy in the long run, lack of serious interruption to use of road, ease of repairs and renewal.

Satisfactory results have been obtained under this method, and it is believed that it offers an easy and economical way of revivifying a macadam or gravel road otherwise about to need resurfacing at a far greater cost.

Snow removal this winter in New York City has cost $1,150,000. The regular contractors' outfit engaged on the work totalled 2,500 men and 1,200 carts. The emergency gang was composed of 9,000 men, besides the 3,000 regular street cleaners. Motor snow plows to the number of 120 aided in the work. Wherever possible the snow was disposed of in sewers.

Letters to the Editor

Placing Concrete in Frosty Weather.

Sir,—In your issue of February 24th there appears an article entitled "Concrete Pipe Tunnel, N.T.R., Quebec," by Mr. C. V. Johnson, A.M.Can.Soc.C.E.

This article is exceedingly interesting in that it deals with the question of depositing concrete during frosty weather—a subject which, in this country with its long and intensely cold winters, is one of supreme importance. That concrete in large masses, such as heavy dock walls or bridge abutments, may be safely deposited during periods of considerable frost, provided that precautionary measures are taken, is fairly well established; but a special interest centres in Mr. Johnson's article because the work described was a pipe tunnel having side walls only 12 inches thick, and floor and covering of slabs only 6 inches thick; and the article is rendered really valuable because the author gives the lowest temperature during which concrete was deposited, describes fully the precautions taken to insure the safety of the work, and is able to give assurance that no bad results followed.

It is just this point—the completeness of the information given—which has led me to trespass upon your columns in order to direct attention to the necessity for this completeness on the part of engineers who describe, in your columns or elsewhere, works which they have carried out, if these descriptions are to be fully and lastingly valuable.

The question of depositing concrete during frosty weather is one which at present appears to be in a somewhat unsatisfactory condition. Different engineers have varying opinions as to the limit of temperature, and the precautions necessary, and in practice this frequently works out as little better than "rule of thumb," or the precarious judgment of the moment. As stated above, it is fairly well established that concrete in large masses may be safely deposited during frosty weather under certain precautionary conditions, but it would be highly desirable if this could be narrowed down so as to establish a lowest permissible temperature, and to define the precautions necessary during the mixing and after placing the concrete, so that some approach to uniformity in practice might be attained and the conditions, the result of sure and certain knowledge, laid down in the specifications when tenders for work are invited.

Similarly there could be established the lowest temperature at which it is safely permissible to build in brick or stone, in which, of course, the mortar is applied in thin layers.

At one time, the present writer was engaged for some 12 years in the construction of dock, harbor and pier works on the northwest coast of England. These works were almost entirely carried out in concrete and stonework. The setting of stone masonry was stopped as soon as the temperature reached the freezing point; and no concrete was allowed to be deposited, even in large masses, after the temperature had reached 4° below freezing point, or 28° Fahr., and only then when the newly deposited concrete would be immediately covered by the rising tide, and remain submerged for several hours. Of course, no precautionary measures, such as heating the materials, were taken, though occasionally the sea-water was used in mixing the concrete. It need scarcely be added that under such conditions none of the concrete ever showed any signs of deterioration from the effects of frost; but it is quite clear that such extreme caution is unnecessary, and would be well-nigh impossible or impracticable in this country. By heating the materials and protecting the new work concrete may safely be deposited at a much lower temperature than 28° Fahr., and it only remains to establish the lowest temperature and the protective measures necessary under the extreme conditions.

There must be many engineers in the country who have had large experience in this matter, and who, doubtless, have much valuable and detailed information in their possession. If such engineers would publish more freely the results of their experience in full detail, and if these details of various conditions and results were collected and made readily accessible, something approaching the lowest permissible temperature and the necessary protective measures might be reached.

The thought suggests itself that the preliminary step —that of collecting exact information—might very properly be taken by the various branches of the Canadian Society of Civil Engineers, each branch working amongst its own members. After this, the results might appear in the transactions of the parent Society, and the information would thus be placed in the hands of the great majority of engineers throughout the country.

JOHN B. HARVEY, M.I.C.E., M.Can.Soc.C.E.

Ottawa, Ont., March 28th, 1916.

Stresses in Lattice Bars of Channel Columns.

Sir,—We may distinguish between the loads that lattice bars normally carry and the loads for which they should be designed, in order to make the design of a column consistent as a whole. It is the latter problem that Mr. Pearse has sought to solve.

It may be well to review briefly what we know regarding the actual stresses in the lattice bars of columns that have been tested and what bearing these results have upon design.

In Bulletin 44, Talbot and Moore give results of three tests of the lattice bars on each of two columns. Column No. 1 was of steel built for the tests and designed slender to show the phenomena expected. It had two plates 20″ x 3/8″, four angles 2″ x 2″ x 1/4″, and two rows of single lacing. Column No. 2a was of wrought iron and had seen service in a railway bridge. It had two channels 10″ 30lbs., and two rows of double lacing. The strain gauges were attached to the lattice bars in such a way that they gave the average strain over the entire section of each bar in the gauge length used. For the five bars that showed the highest stress in each test the authors of this bulletin estimate the equivalent ratio of the transverse shear to central column load as follows:

Column 1			Column 2a.		
Test 5.	Test 14.	Test 15.	Test 11.	Test 12.	Test 13.
0.020	0.010	0.009	0.029	0.027	0.021
0.009	0.010	0.009	0.024	0.019	0.016
0.008	0.010	0.007	0.023	0.018	0.014
0.008	0.009	0.006	0.010	0.018	0.014
0.007	0.009	0.006	0.008	0.018	0.011

In the early use of Column 1, it failed unexpectedly under a slightly oblique load; the alternate lattice bars buckled in one half of the column; the lattice bar loads were not determined by tests upon them, but compression tests had been made on similar bars and the lattice bar load was estimated from these compression tests and it is given in the bulletin as "Probable Maximum Load on Lattice Bar in Pounds, 2,100." It is this result that Pearse has used to confirm his results.

Column 1 was tested in cross-bending also; the "under" lattice bars that were in compression were found to have a maximum stress in each from 39% to 72% greater than the average stress in the bar, while in the "over" bars that were in compression the maximum stress was from 131% to 450% greater than the average stress.

Tests of large columns by Howard, given in Trans. Am. Soc. C.E. for 1911, show insignificant stresses in the lattice bars observed.

Vol. 16 of the Proceedings of the American Railway Engineering Association gives results of tests upon seventeen lattice bar columns conducted at the Bureau of Standards. One was a large plate and angle column, the others were channel columns. The lattice bar strains were erratic, generally small, and compressive in most cases. While the columns did not show much transverse shear, we may express the results in terms of the transverse shear that would be expected to give the same strains and we may express this transverse shear as a fraction of the column load. With a load increase of 28,000 lbs. per sq. in. on the heavy column, the maximum shear indicated was about 0.8% of the column load. The smaller columns under different load variations from 14,000 to 29,000 lbs. per sq. in. showed different maximum values of shear, the average of which is about 0.9% of the column load and the largest value that appears to be normal was about 1.6% of the column load. The per cent. of shear seems to increase with increase of slenderness ratio, and for columns of the same slenderness ratio it is smaller for heavy columns than for light columns. Column No. 17 showed an abnormal lattice bar strain with a load increase of 14,000 lbs. per sq. in., but this lattice bar showed little strain for subsequent heavier loading.

It is believed that the results of these recent tests do *not* warrant the conclusion that lattice bar loads should be materially decreased in the design of ordinary columns. The most of these columns were made under stricter specifications regarding workmanship than are common. They were carefully adjusted to their bearings by highly intelligent men. They were loaded by means of a testing machine of unusual accuracy and rigidity. They were all tested with flat ends. It is apparent that the strain gauge lines were on the exposed side of the various lattice bars; Talbot and Moore found that the strain on one side only of a lattice bar may differ very widely from the average strain over the section of the bar, and we should naturally expect the strain on the exposed face to be smaller than the average strain. Perhaps these tests may be looked upon as indicating the lower limit of what may be expected in the way of lattice bar loads *that result from column loads.*

It may be admitted that the present method of assigning loads to lattice bars, such as by Pearse's Equation (d), is not logical. We have not learned that it has given unsafe results. The chief difficulty in trying to get up a consistent method for the design of a column is that different people do not agree upon the meaning of column formulas. I do not think the stress that Pearse designates by S_0 should be considered constant for columns of different slenderness ratios or for columns of some different types of cross-section.

Admitting that Pearse may be right in this respect, he has erroneously introduced a factor 2, that makes all of his results twice too large on this score. Then his equation 7, as applied to the actual length of the column, can hardly be admitted for his purpose. Many people have assumed this equation for the column curve and for certain purposes it matters very little; but that is not true in this case. If a column deflects with no part overstressed and at a load less than that given by Euler's formula, it is because its load is not central. Its axis takes the form of a portion of the sinusoid curve; the whole sine curve extends to the greater length that a column of the same section would have in order to be about to fail by buckling under the same load, the Eule length for this stress. For the columns and average stresses given below the lattice bar loads given by Pearse's formula should be multiplied by the factors indicated.

Slenderness ratio L/r	Average stress S_1	Correcting factor
20	13.325	0.01
40	12.825	0.05
60	12.050	0.10
80	10.835	0.16
100	9.200	0.21

The resulting lattice bar loads would be so small that in many cases we might expect the lattice bars to receive larger loads in transportation and erection. I suspect that Talbot and Moore were not far from right when they concluded in Bulletin 44: "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations or on data now available."

This futility should not lead us to close our eyes to the possibility of certain loads that can be roughly approximated. A column must be transported and erected; it may be at the bottom of a pile of bridge or building material and should be capable of carrying a good load in addition to its own weight. Some of the lattice bars may be so badly bent that they can carry little load; the adjacent bars should be amply strong.

A channel may not be initially straight; if it is straight before punching holes in its flanges it will not be so thereafter. Riveting tends to bend members more than punching does. It is safe to say that very few channels of latticed columns would remain straight if the lattice bars were sawed in two so that each channel could take its natural form without restraint. In columns, these channels are held to straightness, insofar as they are straight, by the lattice bars, arranged with the channels in triangular truss elements. Some of the lattice bars must carry load due to this service which they perform. If the channels would bend into circular arcs on being released from the lattice bars, we can see that the lattice bars that are near the ends of the column would carry loads due to this bending of the channels, but the intermediate lattice bars would be comparatively free from

such load. In general, we should expect the channels to be bent rather irregularly.

It may be worth while to point out approximate relations between these loads and the channel deflections. Let us take the channels given in Pearse's table, same distance between channels, with two rows of single lattice bars inclined 60 degrees with the column axis. Take the channels initially straight and let one of the channels be deflected 0.001 inch by the lattice bars attached to one point of one channel flange, this deflection being forcibly caused by the lattice bars. If we consider the channel as acting like a simple beam of two panels length loaded in the middle, we find the force in each lattice bar to be rather more than 100 lbs. for this small deflection. If we consider the channel as a continuous beam extending over several panels, it is evident that the lattice bar load will be considerably increased; in making an approximate solution by means of characteristic points I found the load for each lattice bar to be about 250 lbs.

One can estimate the maximum deflection that these channels can take before they reach the yield stress; using a yield stress of 30,000 lbs. per sq. in., my estimate for this is approximately 0.001 inch for each inch of depth of the channel. After these values have been checked, they can be used to estimate the maximum possible fabrication loads of the lattice bars of channel columns.

It will be noticed that these fabrication loads cannot be determined by strain gauge measurements upon columns under test loads; they may be estimated by means of such measurements made at the time of fabrication; I do not know if such tests have been tried.

If a single lattice bar is too long or too short by 0.001 inch it will tend to throw the channels out of line, and in the above set of channel columns, this bar will carry a load of about 125 lbs., the channels being regarded as continuous beams. Since this sort of an error throws the channels out of line, this bar will have to carry a portion of the column load. If the error in the bar is 1% of its length, the load in this single bar due to column load is about ⅝% of the column load.

It is to be hoped that fabrication stresses will receive much more attention in the future than they have heretofore received. It is believed that their investigation will reveal many of the reasons why we must use large factors of safety; they may show that our factors of safety as now used are not appropriate to the several structural members.

By way of summary of the views presented above, we may say that it seems improbable that any one formula can now be written for lattice bar loads that will give appropriate results for all conditions; that in assigning lattice bar loads to be used in the design of some particular set of columns it may be appropriate to express the lattice bar load by three terms: (1) the first term may depend upon the carelessness of fabrication and upon the stiffness of the main members of the column; (2) the second term may depend upon the carelessness of fabrication and upon the column loads; and (3) the third term may depend upon the general proportions of the columns; while the sum of the second and third terms should not be smaller than another term which may depend upon the general proportions of the columns and upon the rough handling to which they may be exposed in transportation, erection, and use.

O. H. BASQUIN,
Professor of Applied Mechanics,
Northwestern University,
Evanston, Ill.

March 27th, 1916.

EFFECT OF ALKALI ON CONCRETE.

The engineers of the United States Reclamation Service are investigating the effect of alkali waters and soils on concrete. In the Reclamation Record for February some preliminary conclusions are presented. Sulphates, especially of magnesium and sodium, were found to be the most active in producing disintegration.

Two extreme cases may be cited in the Sunnyside and Belle Fourche projects. Of a number of test specimens exposed on the former no disintegration was observed at the end of about eleven months, with the exception of a specimen containing a soap and alum solution in the mix. The specimens were all of a 1:3:5 gravel mixture. Furthermore, none of the concrete structures on this project have been affected. On the other hand, various mixtures exposed on the Belle Fourche project were all found to be disintegrated at the end of eight months, with the exception of a 1:2 mortar specimen, which was not affected. Concrete structures in this project have also been disintegrated by alkali.

Analyses of samples from the Belle Fourche project show magnesium and sodium sulphates present in strong solution, with the former predominating, and samples from the Sunnyside project show sodium sulphate only, and in much lighter solution. As a general proposition, it must for the present be concluded that in locations where alkali containing these salts is present, special precautions must be taken to prevent its possible action, unless experience with structures previously built has shown no deleterious effect.

Lean mixtures of concrete are more susceptible to disintegration than rich mixtures, and those which are scientifically proportioned as regards cement and aggregate give the best results. This is to be expected, as with scientific proportioning the percentage of voids is reduced to a minimum, thereby preventing seepage of the alkali-laden water into the body of the concrete.

Experiments have shown that the more nearly impervious the concrete the less it is disintegrated by alkali. It is a natural deduction, therefore, that waterproof concrete will resist alkali action. Such concrete, under certain conditions, may be difficult to produce. Laboratory experiments have shown that it is possible to produce concrete that is practically impervious to water up to 50 to 75 lb. per square inch pressure, and satisfactory results have been obtained in the production of an impervious concrete in the field on structures where special care was taken toward that end.

There are numerous patented waterproofing compounds on the market; there are also being manufactured several so-called alkali-proof cements. A number of these have been tested, but the results have not been any better than those obtained with straight Portland cement. Sand cements also have so far shown no superior alkali-resisting qualities. J. Y. Jewett, cement expert, gives his tentative opinion "that with good cement, with care in the selection of suitable aggregates, with proportioning to produce a rich, dense mixture, and with proper methods of mixing and placing, it is possible to produce a dense, impervious concrete that will withstand the alkali action under ordinary conditions without the use of any special materials for waterproofing purposes." With fairly rich concrete an impervious skin of neat cement or rich mortar, such as is produced by working a flat spade between the concrete and steel or surfaced wood forms, will no doubt also have a decided effect in resisting the action of alkali.

COAST TO COAST

Orillia, Ont.—The new filtration plant which has been under construction for the last year and a half, has been put in operation.

Quebec, Que.—The new Transcontinental shops are nearly completed. The machinery for the power plant only remains to be installed.

Vancouver, B.C.—A movement is on foot to establish an inter-provincial road to link up the coast with the Okanagan and Kootenay valleys.

Belleville, Ont.—In the annual financial statement of the waterworks department a net profit of $74,000 is shown for fifteen years' operation.

Fredericton, N.B.—A bill is before the legislature whose purpose is to compel the Street Railway Company to extend their lines in the parish of Simonds.

Hamilton, Ont.—The city council has definitely put itself on record as being favorable to an overhead bridge as an entrance for the Toronto-Hamilton highway.

Sarnia, Ont.—Leakage in services and mains of the waterworks is costing the city $25,000 per year. It is proposed to have a pitometer survey made to locate the leaks.

London, Ont.—New machinery installed at Springbank dam is capable of pumping 3,000,000 gallons of water per day and can be used as a power generator when needed, developing 200 horse-power.

Ottawa, Ont.—The plans for the future layout of Ottawa and Hull, which have been prepared by the Federal Town Planning Commission, are on exhibition under the auspices of the Ottawa Chapter of Architects.

Quebec, Que.—It is expected that the new Bickell bridge will be opened to traffic by May 15th. The structure is of the bascule type and weighs 200 tons. Provision is made for electric railway, horse and foot traffic.

Guelph, Ont.—Spring floods endangered the big concrete bridge over the Speed River, when a portion of the dam immediately above the bridge was washed out, throwing an immense amount of water against the roadway at the end of the bridge and undermining it.

Ottawa, Ont.—The government has passed an order-in-council prohibiting the export of nickel to any but British countries. The order applies to nickel, nickel ore and nickel matte. It is likely that the International Nickel Company will establish a plant in Nova Scotia for refining purposes.

Montreal, Que.—A petition was presented to the Superior Court by the Mountain Sites, Limited, asking that the city be compelled to fulfil its obligation made when Cote de Neiges was annexed to the city in 1910 by which the city was to open a street from Snowden Junction to Liesse Road.

Halifax, N.S.—At a luncheon meeting of the Rotary Club held recently H. R. Mallison, of the Nova Scotia Tramways and Power Company, Limited, described the plans of his company as regards their power development at Gaspereaux. The turbines will have an effective head of 440 feet behind them and will develop 16,000 h.p.

Toronto, Ont.—The proposed new agreement to be entered into by the York Township Council and the Ontario Hydro-Electric Power Commission relative to the operation of the system in York Township has been discussed by the council with representatives of the commission. The agreement has been practically closed and it is expected that its passage will greatly facilitate the installation of extensions, etc., in the township. Under the old method power extensions for either domestic or street lighting purposes were made by the city following the approval of the Ontario Commission.

ELECTIONS TO MEMBERSHIP IN CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a meeting of the Council of the Canadian Society of Civil Engineers, held March 21st, the following were elected to membership:—

Members.—Binnie, Alex. Thos., Victoria, B.C.; Brace, Jas. H., New York City; Hamilton, James, Edmonton, Alta.; Ogilvie, Noel John, Ottawa; Teele, Fred Warren, Hudson, Mass.

Associate Members.—Augustine, Alpheus P., Penticton, B.C.; Barnes, Harry F., London, Ont.; Blackwell, R. H. Holden, Toronto; Burfield, Francis Robt., Calgary, Alta.; Chapman, Alfred Saunders, Calgary, Alta.; Craig, John C., Vancouver, B.C.; Daubney, Chas. Bruce, Port Nelson, Man.; Douglas, Ralph H., Edmonton, Alta.; Edwards, Chas. Peter, Ottawa; Gorrie, David F., Winnipeg; Hodgson, Jos. Pollard, Vancouver, B.C.; Stamford, Wm. Leonard, Victoria, B.C.; Worthington, Wm. R., Toronto; Wright, Clifton M., Barbados, B.W.I.

Juniors.—Cox, O. S., Halifax, N.S.; Dodge, Clinton Lowell, Strathmore, Alta.; Hughes, Hamilton Cleaver, Vancouver, B.C.; Keefer, Jos. Alex., Victoria, B.C.; McColl, Samuel E., Winnipeg; Weeks, Stephen F., Vancouver, B.C.

The following transfers also took place:—

Transferred from the class of associate member to that of member—Young, Frank Moses, Fort Steele, B.C.

Transferred from the class of junior to that of associate member—Crawley, Edmund A., Winnipeg.

Transferred from the class of student to that of associate member—Saint, John B., Vancouver, B.C.

Transferred from the class of student to that of junior—Plummer, Alex. Alfred, Vancouver, B.C.; Taylor, W. Harold, Winnipeg.

SLIDE RULE FOR SPECIFIC SPEED OF HYDRAULIC TURBINES.

A new calculating device in the form of a slide rule has been issued by the Wm. Hamilton Company, Limited, of Peterborough, Ont., manufacturers of hydraulic turbines. The slide rule is used for determining the specific speed or type characteristic of a hydraulic turbine runner. The specific speed is the revolutions per minute which would be attained by the runner if it were reduced in all dimensions to such an extent as to develop 1 h.p. when working under a head equal to 1 foot.

The slide rule is well made of white celluloid with black figures and is contained in a handy pocket case of imitation leather.

Water softening by electricity, especially as regards boiler feed water, is attracting the close attention of American engineers. After the softening compound has been added to the water it is circulated past parallel electrodes which are placed close together in order that as much of the water as possible may be brought in contact with the surface of the plates. The ionising properties of electricity separate the compounds into their components, thereby hastening the recombination to form percipitates, which are easily removed. Ten million gallons of water per day, it is stated, may be treated with only 480 watts per million gallons.

Editorial

MAKING GOOD-WILL A REAL ASSET.

Good-will is an item that often means little or nothing in a firm's balance sheet. A century ago, when but few firms were in each line of business in any town or city, good-will was a real and tangible asset in nearly every well-established store and factory. Changes in methods of competition; the growth overnight of huge concerns, with great resources; amalgamations; price agreements; the large number of sellers in every line,—these and other influences have reduced good-will to a mere figure of speech in many cases.

However, occasionally one happens upon a firm that has, by painstaking processes, built up real good-will. Uniform courtesy in all transactions is generally found to be a strong factor in such cases. A representative of *The Canadian Engineer* recently called at one factory in the United States where "good-will" will certainly some day be a valuable asset, if, indeed, it is not so already. The call was upon the A. P. Smith Manufacturing Co., of East Orange, N.J. The object was to secure an advertisement of their water-tapping machines. The advertisement was not forthcoming at the time; yet, because of the great courtesy with which he was received, the paper's representative, when leaving the factory, was nearly as happy as if a full page weekly contract had been signed.

Immediately upon entering the reception room, he was greeted by the following sign, giving most specific information, and radiating hospitality and good-cheer:—

> **INFORMATION**
>
> Our correct name is THE A. P. SMITH MANUFACTURING COMPANY.
>
> Our mail address is Norman and Lawrence Streets, EAST ORANGE, N. J.
>
> Our shipping address is in all cases to be taken from our purchase order form.
>
> Our telephone number is ORANGE SIX THOUSAND.
>
> We make valves, hydrants, tapping machines, valve inserting machines, lead melting furnaces, corporation and curb cocks, repair sleeves, pipe cutters, calking machines, meter testers, removable plugs, pipe indicators, etc. A broad description of our line is GENERAL SUPPLIES AND SPECIAL TOOLS FOR WATER WORKS. In addition to the above, we do general machine work, make patterns, and castings in iron, semi-steel, brass, bronze, aluminum, etc.
>
> The officers are as follows:
> D. F. O'BRIEN, - - *President* M. G. PERKINS, - *Vice-President*
> T. F. HALPIN - - *Secretary* P. A. SMITH - - *Treasurer*
> All of the above, except Mr. Perkins, are located at this plant.
>
> MR. O'BRIEN can be seen, if an interview has been arranged, any day, except Saturday, between ten o'clock and four o'clock.
>
> MR. HALPIN has charge of sales, advertising, office employment, prices on supplies and specialties in our water works line, etc. He can usually be seen on Tuesdays, Wednesdays, Thursdays and Fridays, from one thirty o'clock to four thirty o'clock.
>
> MR. SMITH has charge of buying, charity and other donations, prices on brass and iron castings and machine work, factory privileges, etc. He can usually be seen on Mondays, Tuesdays, Thursdays and Fridays, from ten o'clock to twelve thirty o'clock and from two o'clock to four thirty o'clock.
>
> In order TO SAVE YOUR TIME and ours, it is best, in all cases, to arrange an interview in advance. Please give the boy at the window full information; you will save time by it, as he has orders that he must obey. He will furnish you with a card marked APPLICATION FOR AN INTERVIEW, if you desire it.
>
> VISITORS will be required to have a pass, properly signed by an officer, before admission to the factory will be granted.
>
> APPLICANTS FOR EMPLOYMENT must fill out an application card. Ask the boy for one.
>
> We will appreciate it if you report to us any discourtesy on the part of any of our clerks toward you. Their instructions are to help you as much as possible. We have street directories, maps, etc., and will be pleased to loan them to you on request. We have many trade papers. If you must wait, as unfortunately you will have to, at times, ask for one, so that your time will not be wasted.
>
> We thank the SALESMEN who visit us for the information and many new and good things they have brought to us. We have salesmen on the road and understand.

"Welcome" surely seemed to be written large upon the door-mat. But the courtesy wasn't confined to the sign. It permeated the whole office and factory. It was evident that politeness was the rule, not the exception, from the president to the office-boy. At the close of his visit, the salesman was even taken to the depot in the firm's automobile, which seemed to be kept handy for such purposes!

DEVELOPMENT OF THE TELEPHONE.

The discovery of the principle of the telephone is brought to our notice just now owing to the unveiling of a tablet in Boston. The tablet has been erected by the Bostonian Society and the New England Telephone and Telegraph Company to commemorate the event which took place some forty years ago. A noteworthy fact in connection with the unveiling is that both the inventor, Alexander Graham Bell, and his assistant, Thomas A. Watson, were present.

Mr. Watson relates the story of the discovery, which was accidental, but, as he says, the incident could only have been taken advantage of by a man with clear conception, such as the great inventor had. The discovery was made on the afternoon of June 2, 1876, during experiments in connection with Bell's theory that a current of electricity should vary in intensity as the air varies in density during the production of a sound. Dr. Bell was testing a spring in one of the receivers to ascertain if the pitch was correct. He had pressed the receiver close to his ear and was listening to the faint sound of the intermittent current passing through the magnet, when the transmitter in Mr. Watson's room stopped vibrating. Mr. Watson snapped it with his finger to start it vibrating again. It was this action that was responsible for the discovery. Dr. Bell heard the pitch due to the length of the spring and also the peculiar soft twang, and recognized instantly that the current carrying such a sound was realizing his long-cherished idea.

What had actually happened was that the spring which Watson had snapped had become permanently magnetized and was in condition by its vibration to generate the sought-for undulating electric current, and when the current passed through the magnet of the receiver, which was pressed against Dr. Bell's ear, it set into vibration the spring of that instrument, which spring, being confined against his ear, was in a condition to vibrate as a diaphragm and not merely as a freed reed.

The invention of the speaking telephone, however, was no accident—it was a development of the undulatory electric current.

From this time on, Dr. Bell devoted his whole time to the study of the speaking telephone, resigning his teaching position at Boston University.

Finally, on March 10, 1876, the telephone actually transmitted intelligible words. The sentence was, "Mr. Watson, come here; I want you." Probably if the inventor had thought of the great invention he was making he would have chosen a sentence not so commonplace as the one he used. From the time of this first use of the telephone as a transmitter of the voice the improvement was more rapid. By early summer in 1876 it was possible to converse fluently between two rooms. On the evening of October 9, 1876, the first long-distance test was under-

taken, when messages were carried over a wire two miles long. The commercial success of the telephone was then assured.

Dr. Bell and his assistant possibly have seen the greatest scientific development along any one line that has been the satisfaction of any inventor to see. From the little imperfect room-to-room telephone line they have seen the wonderful lines over which it is possible to converse from Montreal to San Francisco. They have seen the great commercial development due to no small extent to the great inventor by which commercial enterprises have been connected in one great network of wires. It has seldom been the experience of an inventor to see his invention so developed, more especially by himself. It is to be lamented that inventors very often, who make an invention, find it enlarged upon by some other inventor who gets the greater amount of credit and profit. It is to be hoped that Dr. Bell has seen his ideas fully developed and has received all the satisfaction and benefit which he deserves for his great invention.

The blessings which have followed in the wake of Dr. Bell's discovery it would be well near impossible to describe. The world has been made smaller and more neighborly—business has been facilitated to an enormous extent. It is doubtful if any one single invention has contributed so generally to the enjoyment of the people as has the telephone. One can only realize the value and convenience of the telephone when, after having used one for years, he is placed in a position where he cannot have access to it. It is like an insurance policy, " 'Tis better to have it and not need it than to need it and not have it."

PERSONAL.

G. L. PEARSONS has been appointed secretary and general manager of the Goderich Elevator & Transit Company, Goderich, Ont.

H. G. GIRVIN, chief chemist of the Steel Company of Canada, delivered an address to the Hamilton Technical School a few days ago. His subject was "Iron and Steel."

Capt. F. C. KILBURN, of the Signal Corps, Royal Canadian Engineers, who is now in France, has been promoted to the rank of major. Capt. Kilburn was recently recommended for the D.S.M.

W. J. CURLE, of Toronto, has been appointed general manager of the C., W. & L. E. Railway, to succeed the late William Norris. Mr. Curle was formerly connected with the C.P.R. and C.N.R., the latter road having control of the C., W. & L. E. Railway.

MARK WORKMAN, president of the Dominion Steel Corporation, has left Montreal on a trip of inspection to the company's coal and steel properties in the east. He will be away for some time, his intention being to make a thorough survey of the properties, particularly the recent extensions.

Recent changes among the superintendents of the Canadian Pacific Railway are as follows: A. Halkett, superintendent, Kenora, transferred to Moose Jaw; H. H. Boyd, transferred from Moose Jaw to Vancouver; C. A. Cotterell, transferred from Vancouver to Lethbridge; J. M. MacArthur, at present acting superintendent at Lethbridge, is appointed superintendent at Kenora. The officials took charge of their new districts on April 1st.

OBITUARY.

JOHN FLOOK, a well-known contractor of Chatham, Ont., died at his home there last week.

ROBERT DAVIES, proprietor of the Don Valley Brick Works, Toronto, Ont., died on March 22, aged 67.

WILLIAM R. WAGHORNE, manager of the Hydro-Electric System at Wallaceburg, Ont., died on March 23.

GEORGE SMITH, town engineer of Lindsay, Ont., died of heart failure last week while visiting friends in Toronto.

RICHARD FOX, for many years superintendent of the electric light system in Port Arthur, died recently at his home there.

VICTORIA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the regular meeting of the branch last month an interesting lecture on "The Bridges of the Canadian Northern Pacific Railway" was given by J. L. Harrington, M.Can.Soc.C.E., of the firm of Waddell & Harrington, consulting engineers. He described in detail many of the bridges he had designed, making special mention of lift bridges, where the span lifts up vertically, allowing the ship to pass underneath, instead of having the turntable. The lecture was illustrated by a number of excellent lantern slides, showing the completed bridges, the work in course of construction, and details of the work.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The "Panama Pacific Exposition" was the subject of an illustrated lecture before the Edmonton Branch, Canadian Society of Civil Engineers at their regular meeting on March 24. The lantern slides used were loaned to the branch through the kindness of the National Electric Light Association of New York, and showed the wonderful lighting effects secured at the Exposition.

Dr. J. A. Allan, of the University of Alberta, who spent some weeks at the Exposition, explained very clearly the various slides as they were shown.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The regular monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers will be held in the Chemistry and Mining Building of the University of Toronto, on Thursday, April 13th, 1916.

Professor A. P. Coleman, Ph.D., will give an illustrated address on "A Visit to the Mountains of Northern Labrador."

A large attendance is requested to hear this very excellent address.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

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The Canadian Engineer

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IMPACT FORMULAS FOR HIGHWAY BRIDGE DESIGN

PART II.

A DISCUSSION OF THE DOMINION GOVERNMENT AND ONTARIO GOVERNMENT IMPACT FORMULAS WITH SUGGESTIONS AS TO SIMPLIFICATION.

By E. H. DARLING, M.E., A.M.Can.Soc.C.E.

In Ontario, most highway bridges are now built under the Ontario Government specifications, but a few, for various reasons, are designed according to the Dominion Government specifications. In the latter, the impact formula used is the Prichard formula, for all spans.

$$I = \frac{L^2}{L + D}$$

I = impact increment to be added to the live load stress.
L = live load stress.
D = dead load stress.

The maximum unit tensile stress allowed for medium steel is 20,000 lbs. per square inch.

In the Ontario Government specifications the same formula is used but it is reduced by a factor depending on s, the length of span, or the loaded length that produces the maximum stress, thus

$$I = \left(.4 - \frac{s}{500}\right) \frac{L^2}{L + D}$$

The maximum unit tensile stress allowed for medium steel is 16,000 lbs. per square inch. (For the sake of brevity only the formulas for stresses of the same kind are discussed.) This formula has been plotted on Diagram II., being for dead load = zero and for dead load equal live load. The Dominion Government formula is also shown by the two horizontal lines, for dead load equal to zero and for dead load equal to live load.

Now, consider how these formulas work out in practice, but before doing so it is only fair to state that both the above-mentioned specifications will probably be revised in the near future and the following discussion is more of an attempt to suggest improvement than to criticize what most bridge engineers agree in condemning.

Nearly all highway bridges now built are designed for concrete floors and for all spans, say, from 30 feet to 100 feet the dead load is approximately equal to the uniform live load of 100 lbs. per square foot. For longer spans, as this live load is reduced at the rate of one pound per square foot for every five feet increase in length until a minimum of 80 pounds for a 200-foot span is reached, and as at the same time the dead load increases very rapidly, the impact increment soon becomes so small that it may be neglected. But for spans of from 30 to 100 feet it may be seen from the diagram that the impact increment by the Ontario specifications will be approximately from 10 to 20 per cent. of the live load, or only 5 to 10 per cent. of the total load.

By the Dominion Government specifications the percentage of impact increment for the same assumptions would be, for all spans from 30 to 100 feet, about 25 per cent. of the total stress, but as the unit stress allowed is 25 per cent. higher than that allowed by the Ontario specifications, it works out that the former, with impact added, gives the same result as the latter without impact. For all practical purposes the Ontario impact formula might just as well be neglected for all spans over 100 feet.

For spans under 30 feet the concentrated live load usually controls in the design. The impact stresses produced by this load are probably of greater magnitude and therefore of more importance than those of the uniform load. With light wood floors and short spans or stringers and floor beams of long spans the dead load will be small compared with the live load and the impact increment will accordingly approach 40 per cent. of the live load for the Ontario specifications and 100 per cent. for the Dominion specifications, or reducing to the same unit stresses the actual increases are 40 and 60 per cent. respectively. For short spans with concrete floors, which is the usual construction, the dead load is approximately equal to half the live load. The corresponding values for the impact increment are consequently somewhere around 26.6 per cent. of the live load for the Ontario specifications and 33.3 per cent. for the Dominion, and reducing these as before to the same unit stresses we have in percentage of the total stress 17.7 per cent. for the former and 15.2 per cent. for the latter.

The use of s = loaded length, in a formula for concentrated loads produces very inconsistent results. After the distribution of the wheel loads has been figured the load is treated exactly the same as if it passed over the bridge like the uniform load. Take, for instance, in the design of floor beams or the hip vertical of a bridge, s is always taken as two panel lengths. Then, while the rear wheel of a road roller will produce exactly the same static stresses in these members, yet by the Ontario formula the impact increment will be 20 per cent. less for 30-foot panels than for 10-foot ones, even if the dead load were exactly the same in both cases. For stringers the difference is 10 per cent. Is there any logical reason why stringers and floor beams for long panel bridges should be relatively lighter than for short panel bridges when they both are to carry the same road roller?

Another thing that impresses one in examining these formulas is that 25 or 30 per cent. is not much to allow for impact for the concentrated load. A practical example will bring out this fact.

Assume a bridge having 16-foot stringers resting on solid abutments and having a 6-inch concrete floor. The

stringers will be spaced at 3 feet centres and each will be assumed to take half of the concentrated wheel load of 10,000 lbs. The Ontario specifications will require a 10-inch I-beam weighing 25 lbs. per foot.

The deflection under dead load will be .1041 inch.

The deflection under the live load of 5,000 lbs. applied gradually at the centre of the span will be .2082 inch.

The maximum allowable deflection by the live load for a stress of 16,000 lbs. per square inch is .2499 inch, which would be produced by a concentrated load of 6,000 lbs. gradually applied. The total resilience of the stringer available for the live load is therefore

$$6{,}000 \times \frac{.2499}{2} = 749.58 \text{ inch-lbs.}$$

This amount of work will be done by the live load of 5,000 lbs. if it is dropped onto the floor from a height of .025 inch, thus

$$5{,}000 \times .025 = 125.0 \text{ in.-lbs. kinetic energy}$$

$$5{,}000 \times \frac{.2499}{2} = 624.7 \text{ in.-lbs. work in deflecting beam}$$

$$749.7 \text{ total work}$$

In the same way it can be shown that if the live load were dropped more than .15 inch the elastic limit of 32,000 lbs. per square inch would be exceeded.

Fortunately, in actual construction there are many "mitigating circumstances" which greatly modify the theoretical result. The concrete floor slab absorbs work and distributes the load. If the stringer rests on floor beams of a truss span the total drop of the stringer when the live load is applied will be many times its own deflection and the resilience of the truss is thus added to it. This is doubtless one of the reasons why so many shaky old bridges stand up apparently in spite of all theory. Their very flimsiness makes them good shock absorbers. It is not safe, however, to count on this resilience by any means, for if the stringer or floor beam in its vertical vibration is moving upward when the live load strikes it, it is brought to rest and the effect is the same as if it were rigidly supported.

So, while the above illustration must not be taken too seriously, yet it will serve to indicate how little provision is made for rough usage by the average impact formula.

Summing up the preceding discussion, the following conclusions stand out:

1. That these impact formulas are not based on any mechanical law or on practical experiment that would warrant them being accepted as expressing even approximately the true action of live loads on highway bridges. (See *The Canadian Engineer* April 6 for Part I. of this paper.)

2. That the Dominion specifications for the uniform live load with impact added only reduces the stresses to about what the best modern practice demands for static loads.

3. That in practical results there is very little difference which specification is used in spite of the apparent wide difference in unit stress and impact allowance.

4. That by the Ontario specification the impact increment for uniform loads is a very small percentage of the total load and that for spans over 50 feet it soon becomes so small that it might as well be neglected. The uncertainty regarding internal stresses of the materials, secondary stresses, and faulty workmanship, to say nothing of the impact stresses for which it is supposed to provide, are of an order of magnitude greater than the few per cent. added by the elaborate formula. Its use is therefore an unnecessary refinement, even if it gave absolutely accurate results for impact.

5. With reference to the application of these formulas to the concentrated load, no difference is made between it and the uniform distributed load, although their action is very different. The use of s = loaded length, is objectionable in a formula for slow-moving concentrated loads.

6. To provide for the possible impact from the concentrated load and to make an allowance for future increase or an emergency load the percentage of impact increment given by these formulas (the Ontario one in particular) cannot be considered adequate.

Only by an elaborate series of carefully conducted experiments and tests can any final conclusion be reached as to the effects of impact in highway bridges. But the difficulty of getting anything like satisfactory results from even the most carefully conducted experiments would hardly warrant the time and expense required for them. As related above (Part I.) the committee of the American Railway Engineering Association, after making many thousands of measurements and tests, finally recommended the formula for railway bridges that was developed by C. C. Schneider, who had little more than his judgment to guide him. It should be possible for highway bridge engineers to derive from their experience some formula or method which would be accurate enough for all practical purposes and at least be more logical and satisfactory than present methods. It is with this end in view that the following suggestions are made.

In the first place, it is necessary to make certain assumptions regarding unit stresses and loading. The use of high unit stresses make it necessary to provide a more liberal allowance for impact to insure against overstressing the materials. For many reasons it seems desirable to adopt what is now standard for medium steel, namely, 16,000 lbs. per square inch for tensile stresses due to static loads and the corresponding values for bearing, shear, etc.

The choice of loads is more of a matter of judgment and should be carefully considered for each individual bridge. As a large part of the impact increment is expected to provide for uncertainties in the loading and for future increases or emergencies, the choice of a fairly heavy loading will therefore make a large impact increment unnecessary. Fifteen years ago about the heaviest load that the rural highway bridge ever had to carry was the 6-ton traction engine. To-day, road rollers of 15 tons are coming into use all over the country. A new source of trouble is the motor truck which is now made with a capacity up to 20 tons. The chances are that their number will constantly increase and should some substitute be found for the soft rubber tires and roads continue to improve, even heavier loads may be expected. Whereas the traction engine used to make its trip through the country only once or twice a year and could almost be considered as an emergency load for bridges, there is a possibility that the motor truck will become a very important percentage of the traffic along some roads at least. Then, also, the rate of speed of 10 or 12 miles an hour means increased vibration and more wear and tear on the bridges. Some main-road bridges will have to be designed for two motor trucks passing on them, especially if they are long spans with 16-foot roadway or more.

The uniform distributed load, on the contrary, has no tendency to increase. The heaviest concentration of a crowd of people never exceeds 150 lbs. per square foot, while a crowd in motion does not weigh more than 80 lbs. per square foot. True impact from this load need not be considered.

On account of the great difference between the nature and effects of the concentrated and uniform loads the writer believes they should be considered separately, in allowing for impact, and would suggest the following method:—

1. Concentrated Live Loads. In fixing on a maximum concentrated load for a particular bridge one should be selected which is not only probable but that is reasonably possible. It is unnecessary to design a bridge for an emergency load which there is no likelihood of it ever having to carry. To the estimated static stresses produced by the chosen load the writer would add 50 per cent. as the allowance for everything usually covered by the impact increment. The stresses so obtained will control in the design of all spans up to about 30 feet, and it is just as necessary to provide for them in a 30-foot span as a 10-foot span or in a section of a 300-foot span.

2. Uniform Distributed Live Load.—If a reasonably heavy concentrated load is used a comparatively light uniform load can be assumed, for rural bridges. Furthermore, the practice of decreasing the uniform load in proportion to the span for spans over 100 feet seems reasonable and has proven satisfactory in the past. Why not extend this practice and increase the load in the same proportion for spans under 100 feet? This is virtually what is done by the use of any of the straight-line impact formulas, but why waste time over a tedious, meaningless formula when the same result can be accomplished by this simple method? Assume a uniform live load of 80 lbs. per square foot for all spans 200 feet and over. For spans under 200 feet, increase the live load three pounds for every 10 feet decrease in length. This would give us as designing loads to be used without any other impact allowance, 110 lbs. per square foot for a 100-foot span, 125 lbs. for a 50-foot span, 137 lbs. for a 10-foot span, etc. These loads would provide ample strength for congested crowds on sidewalks and for trusses they would give practically the same stresses that have been found satisfactory in the past.

A bridge designed by the above rules, with proper details, will be capable of carrying, without danger, a 100 per cent. overload in its floor system and all parts affected by it, and yet have a light, economical truss, and these are the main requisites for efficiency and long life, as far as they are influenced by design.

While the discussion has been limited to highway bridges not carrying electric railways there is no reason why these rules could not be used for city or town bridges where the speed of loaded cars is restricted to 10 miles an hour.

Excessive allowance for impact is sometimes excused on the grounds that the extra metal adds to the rigidity and leaves a margin for rust, etc. But there are ways of obtaining better results by a more intelligent use of the material, as, for example, the following:—

The usual requirement found in all specifications fixing the minimum size and thickness of material might be extended by requiring that all members be increased 1/16 inch beyond what the figured stresses call for.

More attention should be given to the question of vibration of long members. It would be advisable under some circumstances to use diagonal lacing on all long tension members instead of small tie plates, as now allowed.

All members, and the span as a whole should be designed so that the moment of inertia of a cross-section divided by the length of the member should not be less than a certain ratio. In other words, the members should be designed to resist lateral deflection and vibration.

The lateral bracing should be designed not merely for strength to resist the wind but its deflection as a horizontal truss should be limited to a certain amount under full load. The use of high unit stresses for laterals may be quite safe and economical, but it means greater elongation when loaded and consequently more deflection. Laterals placed at too small an angle with the chords permit deflection.

Attention to a few such minor points would greatly increase the stiffness of a bridge and at less expense than by a wholesale increase of 10 per cent. or 20 per cent. of material in the main members.

Formula #1. $I = \frac{L^2}{L + D}$

Formula #2. $I = \left(0.40 - \frac{S}{500}\right)\frac{L^2}{L + D}$

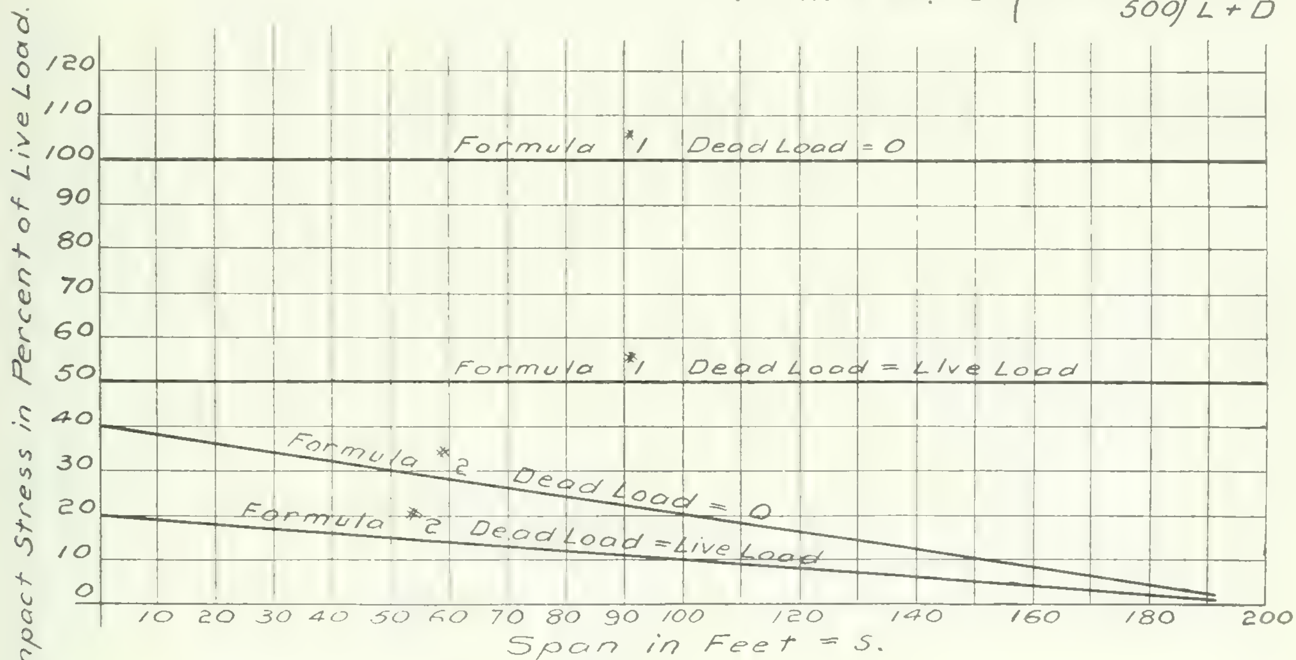


Diagram No. 2.

A METHOD OF TESTING THE EFFICIENCY OF DISTRIBUTION OF SEWAGE SPRINKLER NOZZLES.*

By Edward R. Stapley, C.E.

At the present time, when designs of sewage disposal plants so often include systems of sprinkling filters, the question of obtaining an even distribution over the filter beds is of more than average importance. It is the purpose of this article to bring forth some revised methods by which the efficiency of distribution of various types of fixed nozzles may be determined.

The best possible distribution of sewage so far obtainable is given by moving distributors. These involve either a rotary or a rectilinear motion over the bed. Such types, however, have the disadvantage of being very costly, and difficult to keep in order; and in a very cold climate they cannot be used unless covered because of the complicated parts that freeze readily when wetted.

To overcome these defects the fixed sprinkler nozzle has been devised. These are made usually in either the circular, square, or hexagonal form covering areas corresponding to their respective names.

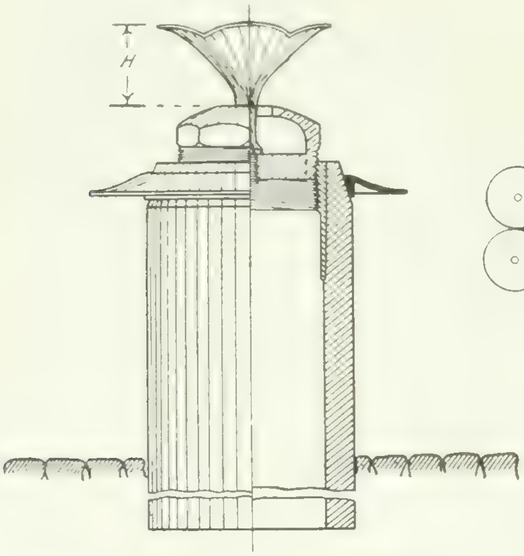


Fig. 1.—Taylor Nozzle and Riser.

By reference to Fig. 2 it is readily seen that, if they do not overlap, circular nozzles placed at the corners of squares can cover only about 78% of the ground.

By staggering, the area of surface covered can be increased to 90%. In the case of the square and hexagonal nozzles, however, it is quite apparent that the whole area can be utilized. For this reason the tests made in the thesis aforementioned were confined to the two latter types.

No matter what form may be adopted it can readily be seen that the higher the head in the dosing chamber the farther the sewage will be thrown as it comes from the nozzle. It has been the customary practice to operate the nozzles in cycles of about ten minutes each, depending on the rate of flow. The total amount of sewage for each cycle is discharged in two or three minutes out of the ten. The best distribution will, of course, be obtained by a varying head. For example, at the beginning of a cycle the tank may operate under its highest head. As the sewage is discharged it will drop to the lowest head and stop. The collecting tank is then allowed to fill up until the highest head is reached when the cycle is repeated.

The length of time that the nozzles are to operate at each head is adjusted by building a dosing tank of irregular cross-section or by means of undulating or butterfly valves in the feed pipes, automatically operated by cams. While the latter may perhaps furnish better regulation, they have the obvious disadvantage of necessitating moving parts.

A photograph showing a general view of the apparatus used by Mr. Field and the writer in their experimental work is shown in Fig. 3.

The apparatus was essentially as follows: A cylindrical galvanized iron tank served as an equalizing reservoir. From the bottom of this tank a 1½-inch pipe fitted with elbows so as to be easy of adjustment led to a point about 30 feet away. Here it was turned up and connected to a 2½-inch bituminized fibre riser in which rested the nozzle. Both inlet and outlet pipes were fitted with valves to give prompt and easy means of regulating the discharge.

Near the base of the tank a brass valve tap was inserted and connected with a glass gauge so as to show the depth of water in the tank.

To determine the head at the base of the nozzle a tap was made with a reducing tee and a hose led from this to a glass gauge fitted beside the stationary tank gauge. After the apparatus was in place, a scale graduated in tenths of a foot to show the elevation above the orifice of the nozzle, was painted on the tank.

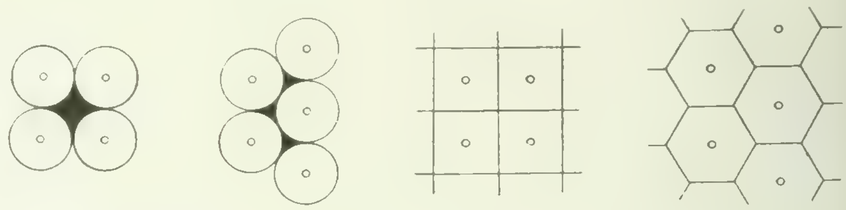


Fig. 2.—Areas Covered by the Different Shaped Nozzles.

The apparatus as constructed allowed of a head at the tank varying from four to nine feet, higher heads than nine feet being seldom used in practice. The effective heads at the nozzle were, of course, much less.

Around the nozzle two lines of rails were built circumferentially and at the same level. Placed radially on these were planks which supported the collecting pans, the whole being so arranged that the upper surfaces of the pans were six inches below the nozzle orifice.

In the experimental work actual measurements were made at points opposite the lobes and notches of the nozzles. The centres of the collecting pans in these lines were placed at points one foot, two feet, three feet, and so on out from the nozzle. In order to facilitate the replacement of the pans after emptying, nails were driven in the radial planks at these points and the centres of the pans marked with paint.

However, in order that a fairly correct idea of the average depth of discharge on different portions of the area served might be known it seemed advisable to have readings at as many as five lines radiating from one side of the square or hexagonal nozzle. These points were distributed as follows, the latter two in this case being interpolated. Two points were taken opposite the notches, one opposite the lobe, and the remaining two at the quarter points. This was done by placing the radial planks in the desired positions.

Due to the method of computation which was devised after the experimental work was finished, it was necessary

* [illegible]

to convert the readings taken in the lines opposite the notches to corresponding intermediate values. In the case of the four-lobed nozzle, depths at points 1.414 feet, 2.828 feet, 4.242 feet, and so on out from the nozzle in the lines opposite the notches were picked from curves plotted from the actual measurements made at the foot points. From this it is evident that the work would have been facilitated and the accuracy increased somewhat by arranging the pans at the desired distances from the nozzle when the run was being made, and also to have had actual readings taken in lines intermediate between the lobes and notches. The reasons for this arrangement of the points at which depths of discharge are desired is shown in the explanation of the method of computation.

As would be readily inferred, the factor of wind has considerable effect on the spray from the nozzle. Such conditions, however, are not at all uncommon in actual practice. If readings are taken at different compass directions from the nozzle, the effect of the wind may be seen and also a fair average depth of discharge obtained. This method was therefore adopted.

Owing to the fact that sewage is not always available for use, experiments may be carried out with water, the results being fairly comparable for all practical purposes.

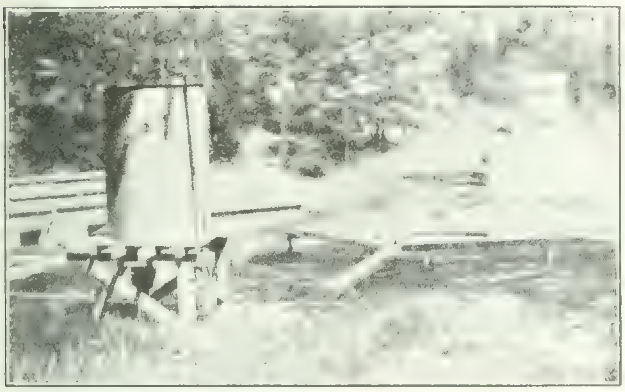


Fig. 3.—Arrangement of Apparatus Used in the Experiment.

In any preliminary investigation it is best to make all runs with constant heads. If thought desirable in order to obtain a better average more than one run may be made at each head. In the tests made constant heads were used, one run being made at each head.

The method of making a run was as follows: The collecting pans being empty and placed in their correct positions and the water in the equalizing reservoir at a certain head, the discharge valve was suddenly opened. The time of opening the valve was noted on a stop watch. By opening the supply valve at the same time, the head in the tank was kept constant. The total head at the tank and the effective head at the base of the nozzle were then noted. At the end of two or three minutes, depending on the depth of water in the pans, the control valve was closed and the depth of water in each pan measured and recorded.

Since the distribution was measured in actual depths at different distances from the nozzle, the measured depths were taken in the convenient unit of thousands of a foot. As it is not always convenient or economical to obtain pans whose sides are vertical, those with slanting sides may be used by making the necessary corrections. The latter type were used in this experiment and the corrections made by means of conversion curves. The pans used, however, should be of a uniform size and shape.

The rate of discharge of the nozzle at any head was obtained by noting the period of time necessary for the water surface in the tank to drop one-tenth of a foot, the supply valve being closed.

The results obtained in the experimental work were arranged according to the following form:

Original Data for Taylor Four-lobed Nozzle.

*Nozzle Setting, H = 0.177 Feet.

Time of Run	Position	Gage Readings Tank	Gage Readings Nozzle	Depth in Pans in 0.001 Feet 1	2	3	4	5	6	7	8	Direction	Rate of Flow
3′	Lobe	5.08′	4.15	0	[illegible]	176	232	51	2	0		West	[illegible]

At the start of the computation work the readings giving the depths of discharge in the various parts of the bed were converted to corresponding average values for one minute of time. As the numbers became rather small, the unit depth was decreased to ten-thousands of a foot. These values were then arranged according to the following form:

Average of Three Directions for One Minute Flow for Four-lobed Nozzle.

Nozzle Setting, H = 0.177 Feet.

Position	Velocity in Riser Ft./Sec.	Effective Head At Nozzle Feet	Depths in Pans in 0.0001 Feet 1	2	3	4	5	6	7	8
Lobe	2.72	4.275	1	32	404	[illegible]	218	0	0	

In testing the efficiency of the nozzles, and as a means of comparison of the distribution under varying conditions, some method by which the relative efficiency of distribution can be measured is necessary. The best method so far devised seems to be that of Phelps, who makes use of a "coefficient of distribution." As originally developed, this idea of a numerical expression of efficiency was applied to tests on circular nozzles only. This was not applicable to the case of four-lobed or six-lobed nozzles, designed to cover respectively square and hexagonal areas. For this reason some new means of expressing the evenness of distribution which would apply to these cases seemed necessary.

To meet this need and also to make it possible to take into account the factor of overlap, which is not considered in the method aforementioned, a modification of the Phelps' method was devised. This modified method, while following the same general theory as the other with respect to the manner of stating the evenness of distribution, differs in that it allows the shape of the area served to be taken into account. The method as devised is given below. In order to make the explanation perfectly clear, a sample computation is given for a four-lobed nozzle.

Calculation of Coefficient of Distribution for Taylor Four-lobed Nozzle by Modified Phelps' Method.—For the purpose of description a 12-foot spacing of nozzles will be assumed, although in the actual computation this does not enter into the work until later and may be varied at will according to the conditions of the case in hand.

The diagram in Fig. 4 shows two nozzles spaced 12 feet apart and placed with the lobes opposite and in line. lines drawn parallel to the common side of the areas served, and midway between the foot points divide the triangular area, forming one-fourth of the total area served by one nozzle, into trapezoidal strips one foot wide with the exception of the outer one which is one-half foot wide and the inner one which contains only one-fourth square foot and may be neglected. The letters a, b, c, d, etc., indicate the depths of liquid at points 1, 2, 3 and 4 feet from the nozzle. Letters a', b', c', d', etc., indicate the depths at points 1.414, 2.828, 4.242 and 5.656 feet

*See Fig. 1 for explanation of "H."

from the nozzle. Letters a'', b'', c'', d'', etc., indicate depths at the corresponding quarter points. These depths are the average of the values read in the experimental work reduced to one unit of time.

The average depth on any strip as $D = 1/5\ (d + 2d' + 2d'')$. The average depth multiplied by the area of the strip gives the discharge on that strip. In the computations all depths or quantities, since the latter may be stated in terms of the depths, are in ten-thousands of a foot.

Average depths on strips for a one-minute flow in 0.0001 feet, using a nozzle setting, $H = 0.131$ feet.

Effective head.	Strips. A	B	C	D	E	F	G
5.622′	2	21	171	374	391	122	0
4.930	0	33	242	401	317	40	3
4.140	0	36	268	539	168	23	1
4.039	5	56	344	619	62	4	
3.355	5	54	579	275	11		
2.683	7	251	863	51	2		

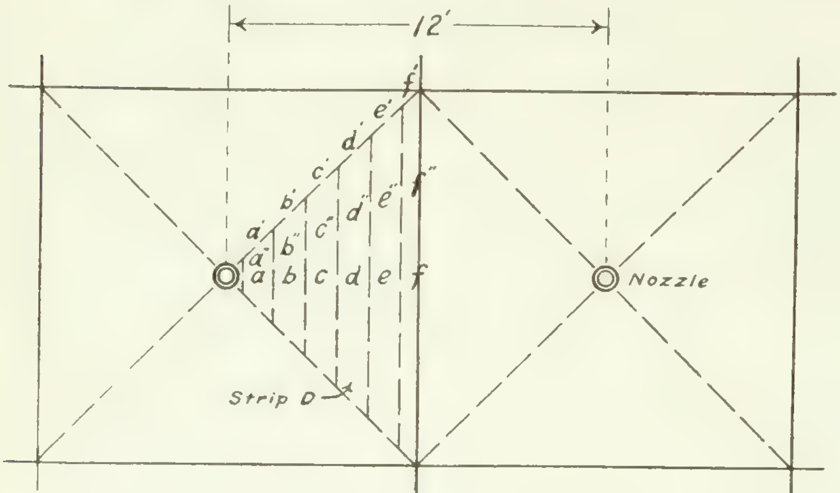


Fig. 4.—Spacing of Nozzles with Lobes Opposite and in Line.

If the nozzle is operated $1\frac{1}{2}$ minutes at 5.622′ head and $\frac{1}{2}$ minute at 2.683′ head, we have:

A	B	C	D	E	F	G
3	31	256	561	586	183	0
3	126	432	26	1		
6	157	688	587	587	183	0

Adopting a 12-foot spacing of nozzles and taking into account the overlap, we have as the average depths on the various strips:

A	B	C	D	E	F	G
6	157	688	587	587	183	
				9	183	
6	157	688	587	596	366	

Discharge T = (average depths on strips) × (area of strips).

$$\begin{aligned} 6 \times 2 &= 12 \\ 157 \times 4 &= 628 \\ 688 \times 6 &= 4{,}128 \\ 587 \times 8 &= 4{,}696 \\ 596 \times 10 &= 5{,}960 \\ 366 \times 5.75 &= 2{,}105 \\ \hline &\quad 17{,}529 = T \end{aligned}$$

Total area of triangular strip $= 2 + 4 + 6 + 8 + 10 + 5.75 = 35.75$ sq. in.

Average depth over whole area $= 17{,}529/35.75 = 490$.

This value of 0.0490 feet being the average depth of discharge during ten minutes of time, corresponds to a rate of approximately 2,300,000 gallons per acre per day, which is slightly in excess of the 2,000,000-gallon rate commonly employed.

The excess depth on any strip equals the depth on that strip minus the average depth on the area served.

	A	B	C	D	E	F
	0	157	688	587	596	366
			490	490	490	
Excess depth ...			198	97	106	

$$\begin{aligned} 198 \times 6 &= 1{,}188 \\ 97 \times 8 &= 776 \\ 106 \times 10 &= 1{,}060 \\ \hline &\quad 3{,}024 \text{ excessive discharge } E \end{aligned}$$

Coefficient of distribution $= (T - E)/T = (17{,}529 - 3{,}024)/17{,}529 = 0.827$.

In this case the method of operation tending to give the most even distribution seemed to be that of using only the high and low heads.

A similar method of procedure was followed in the case of the six-lobed nozzle, except that the positions of the collecting pans in the rows opposite the notches and in the intermediate rows were changed to correspond to the six-sided area which was now covered.

Results of Tests.—In the experiments carried on by Mr. Field and the writer, the tests were limited to the Taylor nozzles of the four and six-lobed type. Either one or the other of these two types has been adopted in a large number of modern plants. The reason for confining the tests to these nozzles was that they seemed to cover the ground better than any other type.

The tabulated results of the tests are given in the following table:

Type of Nozzle	Setting	Spacing	Maximum Head	Time	Intermediate Head	Time	Minimum Head	Time	Coefficient of Distribution
4 Lobed	0.131′	12′	5.622′	1.5′			2.683′	0.5′	0.827
4 "	0.155	12	5.586	1.3			2.709	0.7	0.827
4 "	0.177	12	5.975	1.25			2.851	0.6	0.881
4 "	0.200	12	7.554	1.75			3.265	0.75	0.863
6 "	0.135	14	6.018	1.5			2.635	0.75	0.884
6 "	0.160	14	5.964	0.9	3.962	0.4′	2.613	0.5	0.869
6 "	0.185	14	6.214	1.0	4.122	0.5	2.741	0.5	0.838
6 "	0.210	15	7.257	1.25	5.638	0.75	3.340	1.5	0.903

From a study of the above table it would appear that within the limits of the effective heads used in the experiments with the two types, the six-lobed nozzle with a setting, $H = 0.210$ feet, would appear to be the best model to use, if the best distribution possible is desired. The area served by the four-lobed nozzle, however, is about 9.6% greater than that served by the six-lobed type, so that the resulting gain in economy of the installation may overbalance the difference of 2% in the distribution effected. In either case the degree of perfection of distribution is fairly high and the choice would probably go to the one giving the lowest first cost.

In conclusion, therefore, it would appear that it is important not only to choose the best type of nozzle, but also to operate the same under the conditions of spacing

and pressure which will allow of its operating at its highest efficiency. In the majority of cases in actual practice the maximum available head is usually fixed, so that the chief problem for the engineer to solve is to properly adjust the distribution of this head, the length of cycle, and the spacing of the nozzle, so as to give the maximum efficiency, at the same time not neglecting to consider the factor of relative economy of installation. It is believed that the first three of these points may be met to advantage and with a fair degree of ease by the method illustrated.

BITUMINOUS PAVING PLANTS.

By L. Kirschbraun, Ch.E.,
Consulting and Testing Engineer, Chicago, Ill.

ENGINEERING literature of the past few years has been prolific with discussion of various features in the production of bituminous pavements—with types of pavement, methods of construction, qualities of materials and other considerations. Little has been said, however, in regard to the factor of plant equipment used in the manufacture of bituminous paving compositions, and as to the effect, in a general way, upon paving work, of the efficiency of various types of plants in producing good or poor pavement mixtures. The writer proposes to discuss somewhat, the practical effect of this factor of paving plant upon the finished pavement.

Conditions Encountered.—During the writer's experience, situations have been frequently encountered in which contracts have been let for paving work under well-drawn specifications calling for good type of construction, good materials, etc., but when actual construction was commenced, there was found a contractor on the job with a contraption for turning out a pavement, ranging anywhere in character from a "peanut roaster" to a converted concrete mixer. The problem then presented to the engineer, when faced with such conditions, is to produce a good pavement under most disadvantageous and most adverse conditions with reference to plant facilities.

The writer is able to trace a number of instances of bad construction to nothing but this particular factor of inadequate and improper plant equipment, resulting in the production of uneven and frequently totally defective mixture. In fact, this condition has appeared so frequently on account of the large increase in the amount of asphalt construction, and the large number of new and inexperienced contractors entering upon this work, that in the latest specifications, a description has been included covering, so far as possible, the essential requirements for plant equipment. This requirement, as included in the writer's specifications, is given as follows:—

"**Minimum Plant Requirements.**—The paving plant shall be of an approved type, properly adapted for producing the character of mixture hereinafter described. It shall consist of separate units for melting and preparing asphaltic cement, a dryer for heating mineral aggregate, a screen and storage bin, having at least two compartments whereby the mineral aggregate may be separated by means of a 6 or 8-mesh screen into two sizes, that passing through the screen being collected in one compartment, while the rejection is collected in another compartment. Plant shall further be equipped with the necessary devices for weighing separately the fine and coarse aggregate from each compartment of the storage bin. An asphalt cement bucket shall be provided with scales attached in order that the amount of asphaltic cement which is put into the mixture may be properly gauged. The mixing unit shall consist of a twin pugmill mixer or its equivalent with blades so spaced as to produce a thoroughly homogeneous mixture."

This description is intended to eliminate certain types of equipment which are favorably regarded by the inexperienced contractor undertaking asphalt construction, with the idea of simple work and large profits. Plants which fail to meet the above description should not be allowed on a paving job.

It is believed that the formulation and preparation of a good bituminous mixture, capable of withstanding modern conditions of traffic is a matter of sufficient difficulty and involves a sufficiently high degree of judgment and care, to at least call for the best of facilities in preparing such mixtures, and certainly the engineer engaged in such work should not be harassed and handicapped by plant facilities which frequently vitiate and certainly make most burdensome, the successful production of a well-planned mixture.

Changed Conditions.—In the manufacture of paving plants in years past, it is apparent that the producers of such plants were concerned much more with those mechanical features which tended to greater capacity, and ease of mechanical operation, rather than to ease of controlling product. It is only within the very recent years that some attention has been paid to this latter factor, and while this tendency is a matter of encouragement to those engaged in controlling paving mixtures, yet it is apparent that there is much room for further improvement in this direction.

Conditions with respect to plant requirements have changed greatly within the last few years. Asphalt paving construction is being called for by cities of much smaller size than heretofore, and a large amount of road work of mechanically mixed type is being laid throughout the country.

As a result of this wider spread use of asphalt surface, the demand for portable plants, either of railway or road type, has been greatly increased. The permanent plant which was maintained in the larger cities could be set up with facilities for handling materials which are not generally available in connection with the portable plants.

Again, prior to ten years ago, very little asphalt work was done excepting sheet asphalt pavements, whereas in more recent years, types of bituminous pavements have been developed of more complexity, containing stone as well as sand aggregate, thereby necessitating improvement in plant facilities over those available before. It is therefore apparent that as the complexity of our mixtures has been increased and the factor of portability has become so important, more is being demanded of the paving plant to make it adaptable to the latest conditions.

Need of Greater Accuracy.—It is unnecessary to point out the need for accuracy and uniformity in preparing bituminous paving mixture. This is particularly true in the newer forms of construction which include a wider range of aggregates than heretofore. It is well known that variations in uniformity permissible in a sheet asphalt mixture, are frequently disastrous in connection with asphaltic concrete mixtures. These latter mixtures are much more susceptible to variations in content of asphalt cement than are sheet asphalt mixtures, and not only is this true with respect to the mixtures themselves, but conditions of traffic make it necessary to observe finer points in their preparation than has been the case heretofore.

For example, an asphaltic concrete mixture under heavy automobile traffic must be regulated to narrower

limits in composition and within different limits than is the case in a mixture exposed to light traffic of mixed character. These conditions make it more and more necessary to have plant equipment capable of the most accurate work and susceptible of at least as much control as is required for similar manufacture in other branches of chemical technology. These conditions are being met with by the more progressive manufacturers of paving plants.

Lack of Skilled Labor.—Generally speaking, the labor available for the operation of asphalt plants is of very unsatisfactory character, and is not to be entrusted with carrying out any important operation without the closest supervision. This statement does not, of course, apply to the operations of those concerns who continuously carry and carefully break-in the labor controlling the more important portions of the mixture manufacture.

Generally, however, the labor available at the asphalt plant is the kind which is picked up locally, and most frequently such plants come upon the work with scarcely anyone but a foreman having any idea as to operation. These conditions make it essential that the important operations in turning out these mixtures be so arranged as to be subject to almost automatic control, so that the labor available need not be depended upon for the success of the work.

In other words, the paving plant should be made foolproof, or as nearly so as is possible with reference to those features which enter into the control of product.

The result of crude facilities and poor labor is that with the best of intentions, and frequently with the best of efforts, inferior results follow simply because, in the final analysis, the pavement mixture, however well planned or however well set, is dependent for its accurate proportioning upon the man at the mixer, who frequently holds his job because no one else will stand the dust, dirt and heat of this portion of the work.

The writer has been often amused when visiting paving plants to find, upon asking the plant foreman as to his mix, a ready response in odd and exact figures of different materials used, and then to climb up on the mixer and find the gentleman of color presiding there, overdrawing his A.C. bucket ten or more pounds, the bucket carrying a choice accumulation of dirt, its tare a matter of ancient history, the amount of filler dependent upon half-filled buckets of variable number, and a general promiscuous intermingling and wandering of various aggregates from their respective bins.

The box weights given by the foreman with so much assurance and emphasis on the ground become a matter of chance and purest guesswork at the mixer. Without an inspector almost continuously at the mixer, the well-planned proportions and the careful judgment used in making the mix become a theory, subject to the vagaries of totally unskilled and unreliable laborers.

The Requirements.—The important operations of a paving plant, from the point of view of the engineer, may be briefly stated as follows:—

(1) Melting of refined asphalt and fluxing to produce asphaltic cement.

(2) The proportioning and feed of cold aggregate into the dryers.

(3) Control of temperature of aggregate and of asphalt cement.

(4) The separation of complex aggregates and distribution into various bins.

(5) The weighing out and combination at the mixer of the components of the paving composition.

The ideal paving plant will approach the maximum of efficiency in proportion to the extent that these operations may be controlled automatically or with the least possible dependence upon the labor employed.

If the attention of the manufacturer of paving plants be directed towards these features rather than to further improvement in capacity, a great deal will have been accomplished for the benefit of the paving industry. As a matter of fact, the later types of standard plants on the market have generally little to be desired as to mechanical reliability or capacity of output. There is even a tendency for some of these plants to turn out more material than can be given proper attention in laying, so that the time is ripe for more important development in the way of control of product.

How to Meet Requirements.—The writer desires to point out somewhat generally the character of mechanical devices which he has in mind with reference to accomplishing the above-mentioned important operations. In doing so, however, he desires to disclaim any mechanical ability or knowledge of details by which these rough ideas might be carried out.

Asphalt Cement.—With reference to preparation of asphalt cement, there is nothing wanting in the best types of present plants. The refined asphalt is melted by steam or indirect fire, and the fluxing operation is sufficiently well regulated by weighing out the required proportions of materials and agitating them mechanically by air or steam until homogeneous. Generally, there is very little danger of overheating. The temperature of the asphalt cement can be subject to very considerable ranges without injury.

Feeding Aggregates.—The proportioning of cold aggregates into the dryers, as now carried on, is accomplished generally by bringing up to the cold elevator, and piling there, the individual elements of the aggregate. From these piles, one or more men feed the material into the elevator by means of shovels or hoes, regulating the proportioning by the number of shovelfuls of material from each pile. Sometimes this is also done by bringing up the material in wheelbarrows and piling the different portions in one pile, the proportion being regulated by the number of wheelbarrows operating from the stock piles of individual aggregates.

In either case, the labor employed in accomplishing this result cannot be depended upon to maintain correct proportions with measuring units which are, to say the least, crude at best. Very frequently, the wheelers drop out of line or out of order, leaving the other feeders or wheelers working, regardless, at their respective materials. Sometimes the cold elevator will be carrying one element of the aggregate almost entirely, and again, some other element will be carried in preponderating proportion.

This lack of uniformity produces a constantly varying temperature, in the heating drums. It would seem possible that this operation of feeding aggregates could be accomplished by separate conveying devices, bringing each component from its pile at predetermined rates of feed regulated by interchangeable gears or other simple speed-governing device.

By some such arrangement, the proportions of the aggregates could be regulated accurately and uniformly. Even the filling of hoppers or buckets attached to the conveyers operating from each pile of materials might be simply effected.

Temperature.—The temperature of mineral aggregate leaving the dryers must be controlled within fairly close limits. If the aggregate is too cold, it will not mix

(Continued on page 346).

THE AIR LIFT.*

By Arthur H. Ford.

SINCE the cost of pumping is one of the principal items in the cost of supplying water to the residents of a municipality, every waterworks manager is interested in discussions regarding the relative costs of pumping by different methods. Of late years, the air lift, as a means for raising water from deep wells, has become of such great importance that the writer deems a short discussion of the subject worthy of your attention.

Though air lifts have been used for the past fifty years for pumping water from wells of all depths, the theory of their operation has defied mathematical analysis, with the result that their design is almost wholly dependent on the use of empirical formulæ. This has led to the improper design and operation of many lifts, to the detriment of their efficiency.

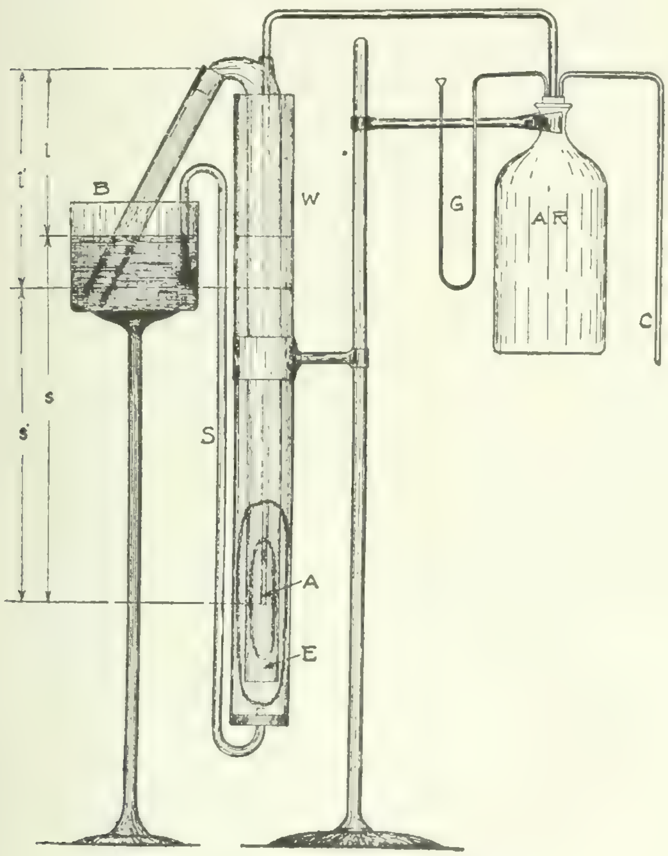


Fig. 1.—Model of Air Lift Pump.

In general, an air lift consists of a water pipe extending a considerable distance below the water level in the well, where it is joined to an air pipe by means of a footpiece. The air pipe is connected to a compressed air receiver, which is supplied with air by a compressor. It is thus seen that there are no moving parts in the well, which makes this type of pump especially desirable for use in crooked or deep wells, where the cost of repairs on pump rods and cylinders is large. The lack of moving parts in the well also increases the reliability, which is a great advantage in those cases where one well only is depended on for the water supply; it also makes it possible to handle water containing so much grit that reciprocating pumps will not answer, because of the excessive wear of the cylinders. Air lifts can pump water faster than any other type of pump, and are, therefore, frequently used for the purpose of testing new wells. The rapid rate of pumping water is such a desirable feature that this alone may lead to the use of an air lift in preference to a pump of some other form.

A picture of a working model of the simplest form of air lift is shown in Fig. 1. The outer tube (W) represents the well; connected to the catchment basin (B) by means of the siphon (S), which represents the water passages in the rock. Inside the well is suspended the eduction tube (E), having the air tube (A) suspended in it, but not reaching quite to its bottom. The air tube is connected to the air receiver (AR), which is supplied with a pressure gauge (G) and a connection (C) to the air compressor (not shown).

When the compressor is started, the pressure in the air receiver gradually increases and the water is forced out of the air pipe until it is entirely empty, at which time the air pressure is at a maximum. The air now bubbles out of the end of the air pipe into the eduction pipe, which causes the level of the water in this pipe to rise an amount proportional to the volume of the air in the bubbles. As long as this does not bring the top of the column of air and water above the discharge opening in the eduction pipe, no water will be pumped and the air will merely bubble through the column of water. This condition obtains when the quantity of air supplied is insufficient to operate the lift.

The supply of a larger quantity of air will cause a larger proportion of the mixture in the eduction pipe to consist of air, with the result that the column will be higher, and when the air supply is sufficient the top will be above the discharge opening and the pump will begin to operate. The manner of operation will depend on the relation of the rate at which air is supplied to the area of the eduction pipe. When the rate of air flow is small, the air bubbles will be small in comparison with the size of the eduction pipe and the flow will be steady. Such a flow can be attained only when the pumping head (l) is small in comparison with the submergence (s) of the air pipe.

When the rate of air supply is increased, the size of the air bubbles increases until they entirely fill the eduction pipe and form air pistons, enclosing slugs of water between them. The flow now becomes pulsating; discharges of water and air alternating. Every time that a slug of water is thrown out, the pressure at the lower end of the air pipe is slightly reduced and a quantity of air is emitted. This lifts the column of air and water in the eduction pipe, and at the same time stops the flow of water into the lower end, with the result that the level of the water in the well rises, increasing the water pressure at the end of the air pipe. As soon as the water pressure exceeds the air pressure the air flow stops until the pressure is again reduced by a slug of water being thrown out of the eduction pipe.

The maximum air pressure required to start a lift operating is equal to 2.31 times the submergence (s) of the air pipe, in feet. As soon as the lift begins to operate, the pressure is reduced, because of the drawing down of the water in the well, thus reducing the submergence to s', and increasing the head to l'. (See Fig. 1.) This lowering of the water level may be considerable, and is the determining factor in fixing the economical rate of pumping.

*Read at the first annual meeting Iowa Section, American Waterworks Association.

A number of the factors which enter into the efficiency of an air lift must of necessity be determined by experiment on the particular well in question; but some of them admit of generally applicable determinations being made. Among these is the best form of footpiece, as the connection between the air pipe and the eduction pipe is called. There are a number of forms of footpieces on the market, for some of which extravagant claims of efficiency are made; but as wide variations in the efficiency are due to slight changes in the proportions of other parts of the system or the method of operation, such claims are to be looked on askance, unless they are backed up by adequate guarantees. Tests have shown that the effect of a change in footpiece may be to increase the efficiency as much as 50 per cent. when the head is high, with a much smaller increase when the head is low.

The efficiency of even a well-designed air lift is low, varying from 20 per cent. for a lift of 600 feet to 45 per cent. for a lift of 50 feet; and is greatly influenced by the ratio of the submergence of the air pipe to the lift, the best ratio being about 2. This is clearly shown by a test of a well at Hattiesburg, Mississippi. In this test the speed of the air compressor was adjusted so as to keep the rate of flow of water constant, while the length

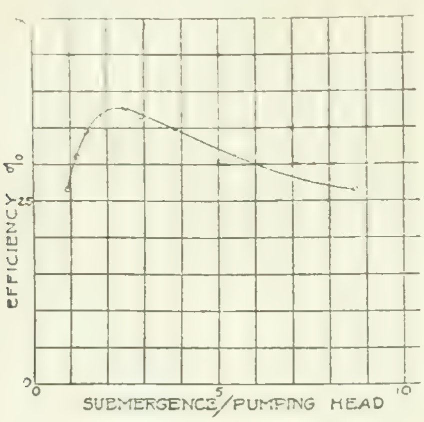


Fig. 2.

of the air pipe was varied. The data are given in the following table and shown in Fig. 2.

Total depth of well	453.5 feet.
Inside diameter of casing	9⅝ inches.
Inside diameter of air pipe........	2½ inches.
Inside diameter of eduction pipe...	9⅝ inches.
Static lift (l)	4.0 feet.

Effect of Submergence on Efficiency Pumping Head.

Submergence.	Efficiency.	Submergence.	Efficiency. Per cent.
8.70	26.5	1.86	36.8
5.40	31.0	1.45	34.5
3.86	35.0	1.19	31.0
2.91	36.6	0.96	26.5
2.25	37.7	....	....

Flow, about 1,100 gallons per minute; pumping head, about 37 feet.

These results show that the maximum efficiency is secured when the submergence is 2.5 times the lift, and that the efficiency falls off more rapidly for a reduction in the submergence than for an increase. It is a good plan, therefore, to have the submergence more than that calculated for the best efficiency rather than less. This allows for the usual occurrence, *viz.*, that the pumping lift increases as more wells are sunk or during a dry season.

Previous to this test the length of the air pipe in this well had been varied with a view to finding out the best flow at which to operate the well. The important data are given below and plotted in Fig. 3:—

Length of Air Pipe. Feet.	Flow. Gal. per min.	Pumping Head. Feet.	Efficiency. Per cent.	Duty. Gal. per h.p. hr.
224	1,495	47.5	32.6	1,630
208	1,459	45.8	31.5	1,640
184	1,419	44.3	31.1	1,670
162	1,359	39.4	30.0	1,790
142	1,299	37.7	30.6	1,920
124	1,219	37.5	32.8	2,070
105	1,106	37.1	30.7	2,340
86	1,008	32.5	33.4	2,450
79	904	29.3	31.3	2,530
67	802	26.0	30.5	2,750
43	600	21.2	29.8	3,240

Fig. 3.

The air supply was apparently adjusted so as to get the best efficiency for each submergence.

This test shows an anomalous variation of the relation of pumping head to rate of flow, which is probably due to the coming into action of a second water-bearing stratum, there being two cut by the well, when the level of the water had dropped 33 feet on account of the operation of the lift.

The writer believes that pump duty, water pumped per unit of energy supply, should be made the criterion of operation rather than mechanical efficiency. He has, therefore, calculated the last column.

This shows that the duty of the lift increases as the rate of pumping is decreased, which is due primarily to the decrease in the pumping head. The variation will be small for a free-flowing well, or one in which the drop

due to pumping is small in comparison with the pumping head. This dictates that the well should be pumped at the minimum rate at which the desired quantity of water will be furnished.

When the well under discussion is operated at a flow of 1,106 gallons per minute, at which flow the maximum efficiency was obtained, the pump duty was 2,340 gallons per horse-power hour; while, if the pumping rate had been reduced to 690 gallons per minute, the duty would have been 3,240 gallons per horse-power hour—an increase of 38 per cent. This would reduce the pumping expense 28 per cent.

The present status of the air lift is such that it can be considered as a thoroughly reliable piece of apparatus; but one should not be installed without the advice of an engineer who has made a special study of the subject, and he should be given opportunity to make trials with various lengths of air pipe and various speeds of compressor operation after the lift has been installed, so as to find the conditions for best operation.

A VISIT TO THE MOUNTAINS OF NORTHERN LABRADOR.*

By Prof. A. P. Coleman, Ph.D.

THE Torngap Mountains in northern Labrador are only 1,300 miles northeast of Toronto, but to get there cost me nearly 4,000 miles of travel. After the rail journey to Sydney, N.S., I took the ice-breaker "Bruce" to Port aux Basques, in Newfoundland. It was her last voyage on the route and she left soon after for Archangel, in the White Sea, where she was to help in keeping open navigation. A crooked railway of 3½ feet gauge took me, in 28 hours, to St. Johns, from which a steamer leaves for the Labrador coast, usually reaching Nain, the central Moravian mission to the Eskimos. From Nain I travelled partly by motor boat, partly on the little whaling steamer "Hump," and partly by schooner, to Hebron, the last settlement of the Moravians on the Atlantic coast. From this point I made my way north in a fishing skiff, with two Eskimos, to Komaktorvik Bay, in latitude 59° 30′, about 80 miles south of Cape Chidley, the turning point to Hudson Straits.

In this chilly, foggy bay I was right among the mountains and did some climbing and exploring in quite unknown territory. The highest mountain climbed reached 4,700 feet above the sea and had three small glaciers on its flanks.

As Komaktorvik is north of the timberline, where hardly even bushes grow, the fuel question was serious. We used partly a little driftwood found on the shore and partly a small oil stove. My Eskimos killed a number of seals and a fine caribou, so that there was plenty of fresh meat when we had fire enough to cook it.

After mapping the surroundings at Komaktorvik we went south in the skiff to Nakvak Fiord and had a wild and stormy voyage. Nakvak Fiord is one of the grandest in the world, to be compared with those of Norway, though its beauty is of a more desolate kind since no trees grow on its wild shores, which rise from the water into mountains of 3,000 or 4,000 feet.

Here, again, I explored and climbed, reaching one summit above 5,000 feet, giving a magnificent view of the fiord and of a sea of barren mountains with many small glaciers and snowfields as well as beautiful lakes.

The finest trout I have seen run up the river here; golden and copper colored and more than two feet long.

On August 25th, we had a snowstorm and I decided to go south. We had a very rough passage to Hebron, where I waited in the mission till the "Hump" came with the mails, and went south on this comfortless little ship as far as Hopedale, the last mission in that direction. Here there was a delay of eleven days, waiting for the "Sagona," which had been held up by storms and fog.

Thousands of Newfoundland fishermen go to Labrador in their schooners every summer, scattering in all the little coves and harbors along the coast and spending two or three months in cod fishing. Their catch was very small last summer, and there must have been poverty in some of the Newfoundland villages in consequence.

Icebergs are very common all the way along the coast and early in the season great fields of floe ice come down from Davis Strait with the Arctic current. I was twice halted by these floes on my way north and found the harbor at Hebron, the most northerly inhabited point, filled with loose blocks and pans of ice when I arrived on July 23rd. Ice conditions will, no doubt, have a very important bearing on the navigability of Hudson Straits.

*Abstract, prepared for *The Canadian Engineer* by Prof. Coleman, of his illustrated address to be given to-night before the monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers, in the Chemistry and Mining Building of the University of Toronto.

INFLUENCE OF TEMPERATURE ON THE STRENGTH OF CONCRETE.

In *The Canadian Engineer* for March 9th, 1916, there appeared an article by H. S. Van Scoyoc on "Concrete Highways Subjected to Extremes of Temperature." Further information relating to this subject is contained in a paper by Prof. A. B. McDaniel, read before the American Concrete Institute. The conclusions drawn by Prof. McDaniel are briefly:

(1) Under uniform temperature conditions there was an increase in strength with age within the time limits of the tests.

(2) It is evident that if the concrete is to acquire a reasonable self-sustaining or a load-bearing strength in a short time (conditions which ordinarily obtain in building work), it is necessary to place the concrete under the most favorable conditions and maintain these conditions during the first few days. Concrete which is protected and maintained at a temperature of from 60° F. to 70° F. will at the age of one week have practically double the strength of the same material which is kept unprotected at a low temperature of from 32° F. to 40° F. Under freezing temperature conditions the materials should be heated so that the concrete will have an average temperature of from 60° F. to 70° F. and the concrete in place kept under an air temperature of not less than 45° F. by artificial heat during the first week. This provision for favorable temperature conditions avoids the well-known injurious effect of the freezing of the water in the concrete, and also the deteriorating effect of the alternate freezing and thawing of the concrete.

Columbia University will hereafter confer the degree of Master of Science upon graduate engineering students who satisfactorily complete the Graduate Course in Highway Engineering. From 1911 to 1915, the graduate engineering students who have specialized in highway engineering have been candidates for the degree of Master of Arts.

BUILDING AND MAINTAINING ROADS WITH REFINED TAR.*

By **John S. Crandell, C.E.**,
Engineering Department, The Barrett Co., New York.

Of the various binders used for road purposes in the last decade only the bitumens have been successful. There are two classes of bitumens so used, and they may be divided into asphalts and tars. The former are found native or may be produced by the distillation of asphaltic oils. Tars are obtained from a number of sources, but those made during the destructive distillation of bituminous coal have given the best service and most satisfaction.

Refined tars for surface treatment of roads have been used during the past fifteen years. With the advent of the automobile came the dust nuisance, and it was in great measure to alleviate this that experiments with refined tars were begun in Europe by Dr. Guglielminetti at the beginning of the twentieth century. These experiments were very successful and led to the tremendous development of the road tar industries of to-day.

Tars are refined for roads and pavements so as to obtain materials suitable for cold application surface treatment, blanket-coat (hot application), the construction of tar-bound macadam and paving pitch filler.

Bituminous roads may be constructed either by the penetration or the mixed methods. By the penetration method is meant spreading and rolling crushed stone to the proper depth, crown and grade, after which hot, refined tar is sprayed over the surface of the broken stone, then the voids are filled with chips and a second or seal coat of refined tar is applied. By the mixed method is meant mixing the heated aggregate and binder together before placing in the road. Both methods give satisfactory results when the construction is properly done, and it is a matter of judgment on the part of the engineer which he selects. Mixed work costs about 25 per cent. more than penetration and requires greater skill and care.

The construction of a tar macadam built by the penetration method will first be taken up. This will be followed by a description of mixed work, and a discussion of maintenance by using a cold surface treatment, which can also be used on water-bound macadam, will conclude the paper.

It is assumed that the drainage problem has been solved and adequately taken care of before the construction of the pavement is begun. The purpose of a pavement of any kind is to distribute the load over the foundation, as well as to provide a waterproof wearing course. The foundation is the earth on which the pavement rests, and it should be thoroughly compacted by rolling; all soft spots should be made firm and unyielding, and the surface of the foundation after rolling should be parallel to that of the finished road.

Base Course.—On such a well-compacted foundation broken stone is spread to a depth of from four to eight inches, depending on the kind of stone and the character of traffic the road is to carry. This is large-sized stone, such as will pass a $3\frac{1}{2}$-inch ring and be retained on a $2\frac{1}{4}$-inch ring. The harder the stone, the smaller the size that may be used. This base course should be thoroughly rolled so that no movement takes place when the roller passes. A 10 or 12-ton roller is best.

*Abstract from address at the International Road Congress, Montreal, March, 1916.

In order to make the base course more stable; to keep the foundation from working up; and to prevent the refined tar, that is applied later on to the next course above, from leaking through, and thus being wasted, the spaces between the stones should be filled with fine, clean gravel, coarse sand or stone screenings. Rolling should be continued, always beginning at the side and working up to the centre. The rolled surface of the base course should resemble a water-bound macadam free from dust.

On this base course either a penetration or a mixed top may be placed.

Penetration Method.—The wearing course is made up of stone, $2\frac{1}{4}$ to $1\frac{1}{4}$ inches, and after rolling it should be $2\frac{1}{2}$ inches in depth. The stone is carefully spread, and rolled so that the surface is smooth and firm. This course is to be filled with tar, so that great care must be taken when soft stone is used to avoid crushing, and thus sealing the surface with rock dust, which would prevent the penetration of the bitumen.

Refined tar will not stick to dirty or wet surfaces. Therefore, the wearing-course stone must be clean and dry.

Refined Tar for Binder.—Not less than $1\frac{1}{4}$ imperial gallons nor more than $1\frac{1}{2}$ imperial gallons of refined tar at a temperature of from 200° F. to 275° F. are then spread uniformly over each square yard of the wearing course. The tar is best applied by pressure distributors, but hand-pouring pots may be used if it is impossible to secure suitable apparatus.

It is very important that the tar be uniformly applied so that the resulting pavement has neither lean nor fat spots in it.

Filling and Sealing.—The spaces between the stones of the wearing course are now filled with ¾-inch clean stone. This should merely fill the voids and not form another course.

Roll again, sweep off any excess stone, and the road is ready to receive the seal coat, which consists of ⅓ to ½ imperial gallon of tar at 200° to 275° F. temperature and is covered with sand or peastone.

Roll for the last time, and the road is then ready for traffic.

Mixed Method.—On the base course, constructed as previously described, can be placed a wearing course made by the mixed method, or such a wearing course may be placed on a concrete base or on a Telford base.

It is necessary to have a mechanical power mixer to properly mix stone and bitumen. There are many such mixers on the market. Some of them heat up the drum with an open flame. The flame should never be allowed in the mixer after the bitumen has been introduced. Portable plants can be had as well as stationary plants, and it is important to choose one that has a capacity suitable to the job.

The advantages claimed for refined coal tar over other bitumens are that it is easily used in the cold-mix type, in which the stone is not heated; that it requires less heat, since the tars have a lower melting point than asphalts, and that the same number of men can turn out a greater yardage per day.

The greatest care must be exercised to see that the temperature is right and that no batch is burned. A burned batch means a bad spot in the pavement that is bound to show up in time.

About $2\frac{1}{2}$ inches of wearing course material is placed on the base course and rolled until it is compacted

to two inches, judgment being exercised as to time and amount of rolling necessary.

Maintenance.—There is no such thing as a permanent road. There is nothing permanent in the universe. The sooner that fact is realized and given due thought by our taxpayers, the sooner grumbling over unmaintained roads will cease. The most enduring structures in the world, whether natural or erected by man, are not proof against the elements, and a roadway, exposed as it is at all seasons of the year to the weather, needs and should receive the best of care.

Just why it is so difficult to make the average man realize that a road needs more maintenance than his house or his office or his barn or his farm machinery is impossible to say. Yet the popular notion still obtains, even among officials who should know better, that once a road is built it is there forever, although their common sense and observation should tell them otherwise.

Maintenance of a tar macadam is such a simple matter that there is little or no excuse for failure to keep the road, once properly constructed, in excellent condition for years to come. All that is necessary is the patching of such few depressions as may need it and the cold application of a light tar yearly, or biyearly, as the traffic may dictate or the condition of the surface may indicate.

The amount of tar necessary to maintain a tar macadam varies from ⅛ gallon per yard to ½ gallon per yard. It is seldom that the latter amount is needed, and where maintenance is the rule, the former figure is nearer the average amount used. In order to get such a small amount as a pint to the yard, a pressure distributor is absolutely necessary. Such a distributor may be made by attaching a system of gearing onto the rear wheels of a horse-drawn sprinkler and connecting this to a pump, which forces the tar out under pressure. Or an auto truck may be used, or even a man-driven pump attached to a barrel may be employed.

The means of application are so many, and the cost is so slight, that it is wasteful economy not to treat bituminous-bound roads when they need it.

Water-bound macadam may be treated and maintained in the same way.

Maintenance of Water-Bound Macadam.—As noted elsewhere, refined tar will not stick to dirty or wet surfaces, so that it is absolutely necessary to sweep and thoroughly clean a water-bound macadam before treating it with refined tar. The sweeping is most economically done with horse-drawn sweepers, followed by men with push-brooms, who remove any crust or scale that may have formed on the surface. It is most essential that the sweeping and cleaning be thoroughly well done, for if any dirt is left on the surface it is to be expected that the tar will peel off at such places. Ruts and potholes should be scarified and repaired in advance of the cleaning.

When the road is dry, ¼ imperial gallon of refined tar, liquid at ordinary temperatures, is applied cold, and, if necessary, broomed in with fibre push-brooms. The application of the tar may be done with pressure distributors or with hand-sprinklers. The former give a more uniform distribution.

Whenever it is possible, traffic should be kept off a newly-treated highway for twenty-four hours or more, after which the surface should be covered with screenings or sand and traffic admitted. In any event, the treated surface should be closed to traffic for at least two hours. Always cover the treated surface with screenings or sand to prevent the tar from being tracked into houses and on to sidewalks. The covering acts like a blotter, taking up the excess tar not absorbed by the road.

This film of tar, which penetrates about ½ inch of the surface, prevents ravelling, prevents the formation of dust, and keeps the road intact. When traffic is heavy, a second and lighter treatment should be given the first year, after which one light application a year should be sufficient to keep the road in excellent condition.

Surface Treatment of Gravel Roads.—Good gravel roads may be maintained in a similar way. In case the road is rutted or pitted it should be scarified and rolled. Two light coats, about 3/16 imperial gallons each, are applied after the road has been swept. The first coat is applied in the morning, followed by the second in the afternoon. Sand or stone chips are then spread, as noted above. Sometimes it is necessary to give the centre of the road a third light coat of tar.

A few barrels of tar should be kept on hand for patching purposes. With surface-treated gravel roads it is very essential that the surface be kept intact, and patching in time saves much annoyance later on, as well as keeping the road in constant good condition.

Tar is not recommended for treating dirt roads.

STEEL COMPANY OF CANADA.

The profits of the Steel Company of Canada for the past year at $3,230,452 were double those of the best previous twelve months' period. Equally gratifying is the fact that 55 per cent. of the company's output during 1915 represents domestic trade. The company manufactures a very wide range of steel products, mines its own ore and finishes its products to the last stages, all of which factors help materially to obtain a good share of business offering at home.

Deducting a sum of $400,000 on account of depreciation, $88,500 set aside for bond sinking fund, $531,000 for bond interest, and $454,741 for preferred stock dividends, surplus profits, after all fixed charges, amount to $1,756,211, equal to 15.2 per cent. on the common stock. Adding this latter to the previous surplus, the amount carried forward at the end of the year is $3,014,641, the largest balance in the company's history, comparing as it does with $1,258,430 in 1914, $1,571,603 in 1913 and $1,060,571 in 1912. The depreciation allowance is substantial, providing as it does for the extra wear and tear entailed by the working of extra shifts. The sinking fund provision of $88,500 is on account of the first payment in this respect, which is due July 1st, 1916, as under the terms of the security a cash sinking fund of 2 per cent. per year becomes operative on that date. The amount now being set aside, therefore, takes care of the six months up to the end of last year. The preferred stock dividend allowance covers two quarters of arrears and two quarters of 1915. The remaining 3½ per cent. arrears, covering two quarters, which were unpaid at the end of the year, have since been arranged for.

The company has materially improved its liquid position. An increase of over 50 per cent. is shown in current assets, these now totalling $9,796,200 as against $6,479,770 at the end of 1914. Cash on hand has grown from $99,407 at the end of 1914 to $182,691 at the end of 1915, an increase of 85 per cent. The company's financial statement generally shows an excellent position.

RAILROAD DEVELOPMENT IN CANADA.

By J. L. Payne, Ottawa.

THE first impression created by a glance at official data relating to the operations of Canadian railways for the year ended 30th June, 1915, is that our transportation interests were hit rather hard by conditions which grew out of the war. On further consideration, however, that impression is somewhat modified. A heavy blow was given to traffic and resultant earnings. There can be no doubt of that; but any depression which might be developed by that fact alone, gives place to relief when the whole situation is carefully analyzed. It is then realized that the railways were able in large measure to meet adversity by adjustment. That is to say, while receipts fell off, there was a proportionate reduction of operating cost. Hence net earnings were fairly maintained. To the intelligent student the results of the past year will be accepted as revealing first-class executive and administrative capacity by our railways. It is stress of weather which tests seamanship, and it is assuring to know that the strength and soundness of our railway situation stood up against the hurricane of 1914-15.

A special feature of the year was the quite unprecedented addition to operative mileage. Everyone familiar with what was going on in the country knew that since 1910 a very large amount of construction work had been under way. Some of the heavier undertakings, such as the National Transcontinental and Grand Trunk Pacific, had actually been started ten years ago. During the four years following 1910 there were 6,063 miles of new line brought upon an operating basis. That was really a significant betterment of transportation facilities—more significant than the unthinking onlooker would suspect. It meant that we had built railway lines beyond the actual need created by swelling population. Nor had such enlargement of carrying facilities been demanded by the pressure of traffic upon existing lines. When the movement began, Canada stood in first place among the nations on the basis of railway mileage per capita. She is still at the top. The tremendous activity in railway building—for by every fair standard of railway measurement it was tremendous—which had been in evidence for years past was an expression of faith in the future of Canada rather than an attempt to meet immediate and urgent needs. Like the charge of the Light Brigade, this faith was no doubt superb; but there are not a few who regard it as, on the whole, imprudent. Time will tell.

An increment of 4,788 miles to operating mileage in 1915 broke all records. Added to the 6,063 miles, to which allusion has just been made, it meant that within the past five years railway mileage in Canada had been expanded by 10,852 miles, or an average of 2,170 per annum. The United States did not do as much during the same period. It is doubtful if the whole of Europe did. This addition was greater than the mileage of the Dominion in 1885—the year the Canadian Pacific was completed—and it brought the total up to 35,582. That total pushed Canada up to fourth place among the nations of the world, only the United States, Russia and Germany being ahead of her. Let us now see how the 10,852 miles of new line put in operation since 1910 were distributed. The following little table will show:—

	Added since 1910.	Present mileage.
Ontario	2,472	10,702
Quebec	882	4,677
Manitoba	1,277	4,498
Saskatchewan	2,395	5,327
Alberta	1,680	3,174
British Columbia	1,268	3,100
New Brunswick	440	1,962
Nova Scotia	16	1,367
Prince Edward Island	6	275
Yukon	11	102
In United States	398	398
Total	10,852	35,582

It should be explained that the mileage assigned to the United States consists merely of sections of Canadian lines which, for purely geographical reasons, cross American territory—such as the well-known Short Line of the Canadian Pacific connecting Quebec with New Brunswick. Look, however, at the table, and see that 6,626 of the 10,852 miles were located west of Lake Superior, or nearly 62 per cent. of the whole. That is where the facilities are most needed, in the area of settlement. It was confidence in the future of our vast and fertile West which impelled this striking construction work.

It will now be in place to see what all this development of carrying power since 1910 has cost; for railways are not built on faith alone. They not only cost a great deal of money, but on a rapidly rising scale. Assuming that the actual cost is closely identified with capitalization, we find that the bill reaches the respectable total of $665,513,201. That is to say, whereas the capitalization of Canadian railways was $1,210,297,687 (as revised) in 1910, it stood at $1,875,810,888 in 1915. But that is not the whole cost. Aid was given in cash by the Dominion, the provinces and municipalities, to the extent of $38,147,848.20, in addition to which the Dominion built the eastern section of the Transcontinental at a cost of $152,802,746. These sums added together make a total of $856,463,795 as the probable cost of railway lines built since 1910; and, to make financing easy, the federal and provincial governments have guaranteed the bonds of railway operations to the amount of $409,869,165 during that period. These are all large and impressive figures, and the outstanding problem at this moment turns upon our ability as a nation of 8,000,000 to carry the liability involved without serious inconvenience. In the last analysis it becomes a matter of earning power. If the railways concerned in this vast capital outlay can meet fixed charges until post-bellum reconstruction has taken place, there is every probability that rising receipts thereafter will remove all ground for anxiety. Meanwhile, the western provinces are in the position of a man who has endorsed the promissory note of a friend, and sees that friend struggling to make both ends meet. To be absolutely candid, we have been just a trifle too optimistic in railway building, and have gone ahead a little faster than Scotch prudence would approve. But the world will witness other grave disasters of a monetary character before Canada, having regard to her resources, finds herself in real trouble because of the faith she has shown in respect of railways.

In 1915 railway gross earnings fell off, as compared with 1914, by $43,240,457. This was largely because freight traffic declined during the year from 101,393,989 to 87,204,838 tons. Gross earnings, however, had been steadily on the ascendant for twenty years. In 1895 they were $46,785,486. Ten years later they stood at

$106,467,198. In 1913 they reached high-water mark—$256,702,703. Not another country under the sun had done relatively as well. Is it any wonder we grew sanguine? A setback had really begun before the war broke out; but with Europe in arms the decline gained momentum month after month. It was under such circumstances that the test of management occurred to which reference has been made. Operating expenses, which had been $178,975,259 in 1914, were pulled down to $147,731,099. Earnings shrank by 17.8, and operating cost by 17.5. The result was that net earnings were brought up to $52,111,973, as against $64,108,280 in 1914. This was a fine achievement, all things considered; but it involved drastic and courageous action. The number of employees was cut down from 159,142 to 124,142. Retrenchments took place in many directions. It was a very trying year. Yet the high standard set for operating conditions was maintained. Roadbed and equipment were not neglected. Our railway managers did not lose their heads and do wasteful things.

The decline in traffic, as has been said, began a few months before the outbreak of war. Ere the people at large knew that a period of contraction in trade had begun the railways knew it. They are always the first to know whether commerce is moving upward or downward. They hold the barometer, and an unfailing, trustworthy barometer it is. Commerce has no particular centre. Foreign trade is registered at the Customs Department; but domestic trade has no point of registration. Railway earnings will always show the trend of both foreign and domestic commerce. These earnings are recorded weekly, and the man who watches them really has his finger on the pulse of national business life. For trade and traffic are synonymous terms. So, let it be repeated, the railways had primary warning of the slump which started early in 1914. It continued until September last. Then the pendulum began to swing in the other direction. War orders and the harvest combined to bring about the change. Instead of one day of thanksgiving, the people of Canada should have been on their knees for a week last autumn. That unprecedented harvest saved Canada from very serious trouble; saved them in a far broader sense than did the demand for munitions.

The upward movement in railway earnings has continued with more or less steadiness since last September. Therefore, without any corroboration from the banks or any other quarter, we know beyond a peradventure that the commerce of Canada has been actively growing. A very substantial part of the losses in gross receipts incurred between March, 1914, and September, 1915, have already been retrieved. This recovery is not wholly attributable to the movement of grain and war materials. Trade in general has answered to the impulse of confidence —that subtle, yet potent, force beneath all enterprise. It is well this change took place. It concerns us all. When earnings are pouring into the coffers of the railways, everybody should rejoice; for railway earnings are invariably and necessarily the reflex of trade. Let nobody grumble when the railways are doing well; the people at large are also doing well. Of course, the fall in earnings last year smashed practically all the nice looking and encouraging averages which had been built up in railway statistics year by year since 1895. It looks at this moment, however, as if many of them would soon be restored to former levels. All the conditions are favorable.

There is another aspect to the decline of last year, and the circumstances which produced it, that cannot be ignored. There will inevitably be a lull in railway building for a time. Caution has succeeded to daring. Nobody knows what adjustments will be necessary when the war is over. Canada is in the best position of any country affected by the war to stand the strain, and Canada, too, is in the best position to receive the immediate benefits of peace. Immigration has been the parent of our railway expansion since the early nineties, and the outflow of population from Europe, when fighting ceases, must come in large measure to our shores. We hold the land available for settlement on attractive terms. But capital will be at too high a premium for some years to make financing easy, and we must not forget that railways are constructed on borrowed money. On 30th June last there were barely 1,600 miles of new line under contract, as compared with many times that mileage two years ago. Not a single new line has been started since 1914. We are therefore facing a period of comparative inactivity. This will afford time for much-needed digestion of the ten thousand miles of railway put into operation since 1910. New mileage is invariably low in density of traffic for quite a period of years. Whatever may be said on the score of prudence respecting our rapid railway building, there is satisfaction in the reflection that we at least have the transportation facilities to make enormous development of our resources practicable. To bring about that development is one of the great problems to which the people of Canada are now called upon to address their energies. They have the power to win.

FUEL-OILS FROM COAL.

Advocating the use of raw tar as engine fuel, and, further, low-temperature carbonization, in a paper on "Fuel-Oils from Coal," read before the Manchester Association of Engineers on February 26, Mr. Harold Moore, M.Sc.Tech., stated that shale oil was a satisfactory substitute for petroleum, but that Scotland produced only 300,000 tons of crude oil per year, whilst the petroleum output of the United States had amounted to 33 million tons in 1913. Ordinary horizontal coal-gas retorts gave from 9 to 13 gallons of tar per ton of coal (about 5 per cent. by weight), while low-temperature carbonization yielded from 10 to 20 per cent. of tar. These figures fall within those quite recently given by Professor Bone. The lighter fractions of the tar distillate were known as creosote, and served both for timber preservation and as fuel for Diesel motors. Tar-oils from low-temperature carbonization being hardly on the market yet, the possibilities of raw tar as engine fuel had to be studied. Raw tars cost about 25s. or 30s. per ton now, which was half the price of the distillate; heavy tars yielded about 25 per cent. of their weight as tar oils, so that the direct utilization as fuel of raw tar, which was made all over the country, and not in special works only, would make four times the material available for power purposes. In calorific power tars were 16 per cent. lower than average petroleum oils. This consumption of tars, like that of heavy petroleum oils, in internal-combustion engines required, however, the use of an ignition oil and a special fuel-pump and atomizer for that oil. These problems had been investigated on the Continent, and Constam and Schläpper had found out that Diesel engines could be run on vertical-retort tars, on chamber-oven tars, water-gas and oil-gas tars, certain coke-oven tars, as well as on lignite tars, but not on tars from horizontal and inclined retorts. Mr. Moore entirely agreed with this conclusion. Requisites for fuel tars were: High hydrogen contents; low contents of "free carbon" (which would wear out cylinders and valves); high calorific power; moderately

low viscosity; less than 2 per cent. of water (to prevent irregular running); low coking value (not over 15 per cent.); and low ash content (not exceeding 0.15 per cent.). The Premier Tarless Fuel Company avoided decomposition of the tar in the retort by working annular retorts with outlets at both ends, under a high vacuum of 25 ins. of mercury at 900 deg. or 1,000 deg. Fahr., and obtained from slack 20 to 25 gallons of tar per ton; from poor cannel coal, 52 to 60 gallons; and from good cannel, 60 to 80 gallons. When dehydrated this tar made an excellent Diesel-engine fuel. Mr. Moore finally suggested to submit the hot gases to fractional condensation by cold in three successive stages; the first stage would yield pitch and free carbon, the second oils, the third the volatile benzene, toluene, etc.; the oils (carbolic, anthracene) of the second stage should give a good engine fuel, which, if too rich in naphthalene, could be preheated in tanks.

EXPERIMENTS IN WATER SOFTENING WITH A ZEOLITE-LIKE SUBSTANCE.*

By Robert N. Kinnaird.

THE application of the chemical exchange properties of zeolites to the art of water softening indicates an important step in the evolution of the art. The peculiar ability of zeolites to exchange their alkaline bases has been known for a number of years. Dr. Robert Gans, of the Royal Prussian Geological Institute, has been the foremost investigator of this group of minerals, and is probably the first to conceive of their applicability to water purification. Dr. Gans and others have measured the exchange capacity of a large variety of natural zeolites, and concluded that the natural deposits were either too rare or too greatly associated with impurities to be of commercial value in themselves. He therefore sought to develop a synthetic product having as large an exchange capacity as possible. His product is beginning to be fairly well known in this country and is coming into extensive commercial use abroad.

You are probably acquainted with the general nature of the process. The synthetic product, in chemical composition, is a hydrous aluminum silicate in combination with sodium. A hard water containing calcium and magnesium salts in contact with this material exchanges its calcium and magnesium ions for the sodium ions in the silicate, the result being that the medium is transformed to a calcium silicate, and the salts carried by the water become sodium salts in combination with the original acid radicals. After the silicate has absorbed its capacity of lime and magnesia, it is restored to its original sodium condition by forcing the action in the opposite direction through the agency of a solution of salt or sodium chloride. Under such conditions as are favorable this artificial product is the basis of an ideal process. Salt is cheap. The chemical application is automatic in so far that fluctuating hardness is self-adjusting. No precipitation of insoluble salts is involved, consequently there is no insoluble sludge of which to dispose. Sedimentation and filtration are eliminated.

The natural substance, which the writer has been investigating, is a hydrous aluminum silicate in combination with calcium, which is capable of exchange for sodium in the raw state at a high rate and to at least as high a capacity as the synthetic product. The writer has succeeded in evolving a method of measurement of the rates of exchange in both directions of the reaction with considerable reliability and accuracy.

Des Moines city water, which has a total carbonate and sulphate hardness of over 300 parts per million, has been softened in experimental filters. In the laboratory of Dr. Edward Bartow, of the Illinois State Water Survey, these Des Moines experiments have been duplicated with the University of Illinois water having a total carbonate hardness of 300 parts per million.

With a filter layer 2 feet in thickness, rates of filtration of 2 gallons per minute per square foot and upwards have been obtained with water of 300 parts per million hardness. This is equal to the rapid sand filtration rates and suggests the substitution of this natural medium either in gravity or pressure filters for municipal use. The requirements for containers and drainage and washing systems would not be unlike the arrangement for rapid sand filtration. More idle time would be involved in the regenerating process than is at present consumed in washing the filters which would increase somewhat the bulk of the equipment. The cost per unit capacity would therefore be somewhat more than the cost of rapid sand filters. The other items of expense would be in the cost of the medium as compared with sand, its life and the cost of salt for regeneration. It is not unlikely that the medium can be produced very cheaply, as compared with a synthetic product. The material with which the writer has experimented requires some refining and hardening to give it mechanical form. The process is not involved and if handled in large quantities can be made to meet a heavy demand at an easily practicable figure.

Present information indicates that 4 pounds of salt can be counted upon to completely convert 1 pound of equivalent calcium carbonate to sodium carbonate, and the writer feels justified in saying that the indications are that this can be reduced. Assuming a ratio of 4 to 1, and 300 parts per million hardness, 10 pounds of salt would be required to treat 1,000 gallons of water. Salt is marketed in car-load lots at $3 and upwards per ton. Assuming $5 per ton, the chemical cost would be 2½ cents per 1,000 gallons, which is easily competitive with lime and soda.

The two processes, however, are not strictly comparable. The zeolite process gives a completely softened water without reducing the total solids. The lime process reduces the hardness by the amount of bicarbonates, while the soda process is only useful in that it converts calcium and magnesium sulphates to the sodium sulphates, which is exactly the same chemical substitution as is made by the zeolite. Either alone or in combination with lime, the zeolite process will be a most valuable finishing process. For waters harder or softer than 300 parts per million the cost figures would vary about in proportion to the hardness. Complete softening would probably be neither necessary nor desirable for municipal use, which would reduce the cost proportionately. For harder waters, the depth of the medium layer could be somewhat increased, sufficient probably to maintain rates of flow nearer the usual rates, without increasing the equipment except as to depth of the containers.

*Read before the Iowa Section of the American Waterworks Association, Iowa City, Iowa.

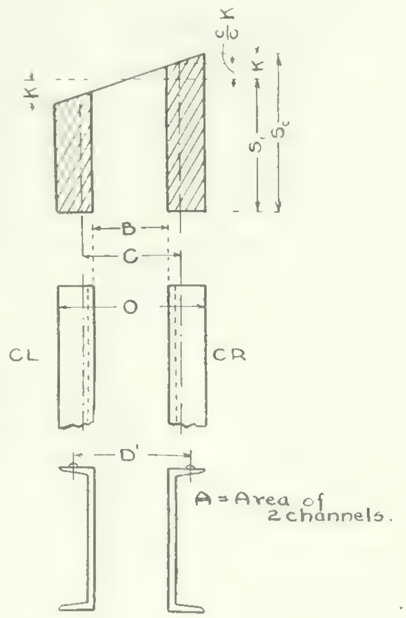
"America's Electrical Week" has been selected by the Campaign Executive Committee as the official name for the great electrical celebration, December 2 to 9, 1916. A start has already been made on the nation-wide campaign which from every indication will surpass even the wonderful results accomplished by the 1915 "Electrical Prosperity Week."

Letters to the Editor

Stresses in Lattice Bars of Channel Columns.

Sir,—In fulfilment of a promise made to you in my letter of March 14th, I enclose herewith a few notes upon Mr. Pearse's paper on "Lattice Bars," published in *The Canadian Engineer* of February 24, 1916.

(1) Fig. 3, page 274, which is intended to show the variation of stress in the two channels, is a bit misleading.



The enclosed sketch gives a somewhat better idea of how the stress is distributed.

Let C represent the distance between the centre of gravity lines of the two channels, which are a distance B back to back and distance O out to out. Then the total stress due to bending in channel marked "C R" is $\frac{A}{2}\frac{C}{O}k$ instead of $2k\frac{1}{2}$.

(2) The distance D' (Fig. 4) appears to represent not only the distance between rivet lines but also the distance between gravity lines and the distance between the resultant total stresses in the two channels as well.

(3) Euler's *long column* formula, Equation 7, for hinged ends, applies to columns for which the ratio $\frac{l}{r}$ is greater than 200, and is of little use for practical investigation. "Column 1," which the author uses to test the soundness of his theory, has an $\frac{l}{r}$ of 37.8, and the greatest $\frac{l}{r}$ of any column in his table (page 275) is 92.

(4) The coefficient of $\frac{l}{r^2}$ of Rankin's column formula, given in Equation 3, is the same as is used in the Dominion Government Specifications, 1908, for a column with one fixed end and one pin end.

(5) It may not be out of place to say that any column formula which contains the factor $\frac{l}{r}$ as a measure of the slenderness of a column should be viewed with some suspicion, for it can easily be proved, either mathematically or empirically that a rectangular column with free ends will not bend in the plane of its least dimension.

(6) The testing laboratory is the only source from which we may ever hope for the solution of the column; and any prophecy eminating from such a source should be given its just weight.

In the laboratory the loads are artificial, the conditions are ideal, and the material and fabrication are usually above the average. Such tests stand much in the same relation to the real problem as the sample packages left at the back door resemble the article produced over the counter.

(7) Since the memorable date of August 29, 1907, over a hundred monographs on compression members have been published, and the conclusions have not always been satisfying. The problem has created as much mathematical discussion as did perpetual motion a generation or more ago.

(8) The structural engineer will be greatly encouraged by Mr. Pearse's paper since it is an indication that architects in some localities at least are in sympathy with the problems of the engineer.

CHARLES A. ELLIS,
Professor of Structural Engineering,
Urbana, Ill. University of Illinois,

Oil-Tar Creosotes.

Sir,—Referring to your editorial of December 30th, 1915, and to Dr. John S. Bates' letter in your issue of February 24th, 1916.

Dr. Bates' letter is an outline of the methods usually employed for distinguishing between coal-tar creosotes and water gas tar creosotes. These *are* the methods usually employed for this purpose, and, as a rule, are very satisfactory in determining the character of *unmixed* oils.

However, as Dr. Bates says, it is not so easy to detect *mixtures*, and, sometimes when the mixtures are made with the intention of deception, it is practically impossible to detect them. The recent introduction of tars produced in vertical retorts and at low temperatures (which are exceedingly good tars) has further complicated this matter of detecting the presence of water gas tar, since these tars sometimes contain a considerable proportion of paraffine compounds.

The whole matter, then, gets back to what the writer has maintained several times; that is, that the detection of addition of water gas oils to creosote is exceedingly difficult and requires a great deal of experience.

AMERICAN TAR PRODUCTS COMPANY,
Per E. B. Fulks, Vice-president.
Chicago, Ill., March 8th, 1916.

Through traffic over the line now being built from Petrograd to the Arctic port of Kola is now possible as far as the rail head at the south-western corner of the White Sea at Soroka, but traffic along this line will be light until it is in full working order. The Port of Soroka is not large, having had heretofore merely local fishing and lumbering importance. It has been subject to all the difficulties suffered by Archangel and caused by the ice conditions prevalent in the "neck" of the White Sea, where it opens through a strait into the Arctic Ocean. In 1913 only 45 vessels put into this port, with a tonnage of [illegible], and the departures were [illegible] vessels, with a tonnage of 47,061. The vessels were extremely small, many being mere barges constructed roughly to carry lumber and intended to be knocked down at the end of the voyage to other White Sea ports.

BITUMINOUS PAVING PLANTS.

(Continued from page [illegible])

properly, and cannot be handled properly on the street. If too hot, the asphalt cement is injured when tossed about in the mixer in thin films upon the overheated aggregate.

In the present plants, change of temperature will occur most frequently through variations in rate of feed or through delays in turning out the material which necessitates shutting off the feed and allows the drum to become overheated. The most common cause of temperature change would be removed by the regular mechanical feed of aggregates as described above.

In any case, it would be comparatively simple to apply to the control of temperature of the dryers, the principle of the electric thermostat which is attached to the draughts of the ordinary house furnace. This thermostat could be so set that when the predetermined upper limits are reached at the boot of the hot elevator, an electric motor would come into operation which would open a trap at the discharge chute from the drum, allowing the mineral aggregate to drop into a screw conveyer, discharging onto the ground.

This conveyer would be interposed between the end of the drum and the hot elevator, so as to remove the overheated material before entering the elevator. Simultaneously, the motor should open the fire doors of the drum, allowing the cold air to enter. When the temperature has dropped sufficiently, and the electric contact is broken, the motor should operate and close the trap, permitting the aggregate again to enter the elevator.

A similar operation could be adjusted for predetermined minimum temperatures.

Present arrangements for control of temperature necessitate taking a sample of aggregate from the boot of the hot elevator and testing it there or at the mixer, and if the temperature is not right, either discharging the aggregate from the top of the hot elevator or from the storage bin. This latter operation is always attended with confusion in shifting teams beneath the mixer or in changing the rate of feed of aggregate. The uniformity of temperature and general satisfactory operation of a plant depends very largely upon the continuity, and anything which interferes to shut down or disturb the mixing operation immediately throws the entire work out of gear, and leads to other disturbances.

Screen and Bins.—Generally, in handling complex mineral aggregates, the proportions are approximately determined at the cold elevator, but in order to avoid segregation in bins or drums, the best practice requires the screening of the aggregate into several compartments and sizes, the number of operations depending upon the complexity of the aggregate.

In most plants, this is not accomplished with sufficient accuracy or with sufficient provision against contingencies which arise during plant operation. Frequently, the storage bins upon these plants are small; and when subdivided into compartments, the operating screen is too short to make a clean separation. Sometimes the partitions are light and do not come up sufficiently around the screens, and when one bin becomes filled, while the adjoining one is nearly empty, there is enough deflection in the partitions to move them beyond the line of division of the screen, permitting one bin to catch aggregate which should drop into the other. Frequently, also, if the plant is not taking material as fast as it might, or if the feed has been varied, one bin will fill up and in the absence of an overflow spout from each individual compartment, material from one bin will crowd over into the next.

It follows, in any case, that in weighing out aggregate from different bins, the proportions set are departed from, and variable aggregate discharges into the mixer, for which the amount of asphalt cement may be entirely unsuited. To correct this condition, it is necessary, when this occurs, to stop the work, empty out the bins, thereby interrupting the smooth operation of the plant and causing disturbances in other directions.

This occurrence is a most frequent one at paving plants, and is the cause of much unnecessary trouble and irregular mixture. In fact, it sometimes becomes so troublesome that it is often advisable not to make a screen separation of aggregate, but to regulate it as closely as possible at the cold elevator. Unless this screen device is so constructed as to operate without causing contamination of the various aggregates with each other, it becomes a source of constant danger. It should be a comparatively simple matter to design this separating unit so that it will actually perform the work for which it is intended.

Mixing.—After the aggregate has been separated into its components and delivered to the storage bins at the proper temperature, the next and most important step is the combination of the various elements into the final pavement mixture.

Until recently, it was common practice to measure the aggregate by volume, either in a box of constant capacity or by striking off an open measuring box. The writer has frequently observed these boxes of constant capacity operating with upper and lower slides, which would not permit shutting off from the bin without first opening the discharge. As a result, a considerable quantity of material over the theoretical capacity frequently passed into the mixer before the upper slide was shut off.

In one case which resulted in a dispute of binder yardage, it was found that the amount of binder actually turned out was 20 per cent. in excess of the capacity of the measuring device, just on this account.

The use of open boxes for measuring is liable to the objection that it requires striking off by the laborer, and this in the long run is slighted. Measuring devices of this kind, as well as volume measurements of asphalt cement, are fortunately almost a thing of the past. It is now customary upon the most modern plants to weigh these various ingredients. Unfortunately, however, the class of labor available for this purpose cannot generally be depended upon for accuracy, even in so simple a matter as weighing, and the result frequently is in error, owing to overdrawing of weights, changes of tare, and errors in handling weights.

The automatic scales on the asphalt concrete bucket should be of a kind which would operate somewhat differently. This should be devised in such a manner that the given amount of asphalt cement will be discharged from the bucket regardless of its tare. This would eliminate the greatest source of error at the mixer, and would result in uniformity of the product of the plant.

It is believed that the foregoing accounts for a very considerable amount of defective or partially defective work which sometimes results in spite of the best of intentions on the part of the paving contractor and his employees. It is further believed that the manufacture of paving mixtures should be facilitated by applications at least equally effective as those available for processes of similar importance. The plant manufacturer who devotes attention to such details will do much toward forwarding the interests of the asphalt paving industry, and his efforts will be appreciated by all responsible for the success of the product of these paving plants.

UNIT CONCRETE CONSTRUCTION FOR MANHOLES, VAULTS AND CATCH BASINS AT ST. JOHN, N.B.

By R. Fraser Armstrong, A.M.Can.Soc.C.E.
Engineer and Superintendent, Department of Water and Sewage, St. John, N.B.

SEVERAL new departures have been made recently by the city of St. John, N.B., in which concrete has played a large part as an economical material of construction. The use of unit concrete blocks in the construction of manholes, catch basins, gate valves, vaults, etc., has effected a saving of from 10 to 40 per cent. of the original brick construction cost, besides making a better and more durable piece of work.

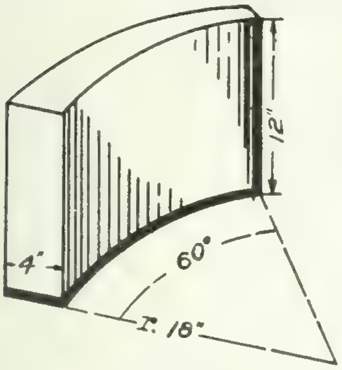


Fig. 1.—Concrete Block, Unit of Construction.

The standard unit adopted is circular in section, 3 ft. diameter on the inside and consists of a concrete block 4 ins. thick by 12 ins. high and forming one-sixth of the circumference of the circle. Each block weighs 96 pounds and is cast in special moulds made for this purpose. A smaller number of blocks are made of different heights, so as to be able to have the top of the finished work conform to the surface elevation of the ground. Each 12-in. block, including material and all labor of casting and cleaning moulds costs 20 cents. (Cement, $2.30 per bbl.; ½-in. broken stone, $1.60 per cubic yard; sand, $1.25 per cubic yard, and labor, $2.25 per day.)

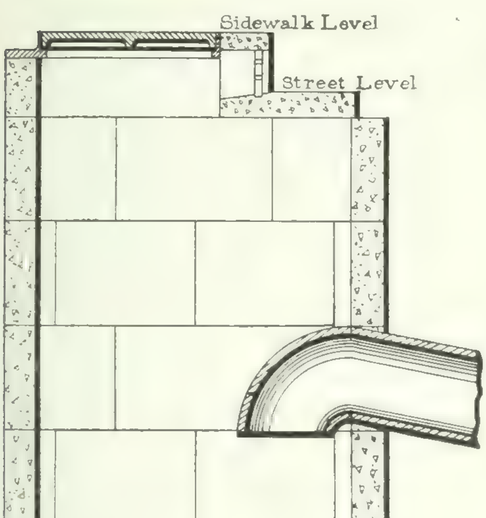


Fig. 2.—Catch Basin Built of Concrete Block Units.

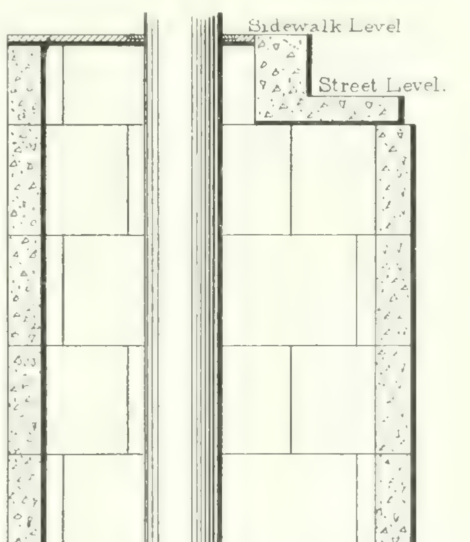


Fig. 3.—Unit-built Fire Hydrant Vault.

In the construction of the catch basins a concrete curb is cast having the inlet opening, fitted with a cast iron grating, in its face. Access to the catch basin is obtained by removing a neat cast iron cover placed in the sidewalk and flush with the asphalt surface finish. These curbs cost 50 cents, including both labor and material, and are similar in design and dimensions to the standard curbs adopted by the street department.

Costs kept upon both the brick and the unit concrete manholes are given below. These costs include all labor and material, but not excavation costs.

Depth of manhole.	Brick construction.	Unit concrete block.
10 feet	$37.00	$27.00
12 feet	43.00	30.00
14 feet	52.00	36.00
16 feet	60.00	39.00

The net saving to the department is greater than indicated above, as these itemized costs allow for the actual labor in each type of construction and make no allowance for the fact that the concrete blocks are all cast by our regular mason and yard laborers in their spare time. It is necessary to keep these men around for emergency work and where formerly all their time was not occupied at necessary work, now all their time is employed to advantage and the portion formerly charged to general maintenance is now charged to concrete block construction.

Another very good use to which concrete has been put is in the construction of a tunnel under the Intercolonial Railway tracks. The nature of the soil at this point is such that a distinct vibrating motion is imparted to the ground as each heavy train passes. Ever since the water pipe was placed, in 1899, it has been necessary to dig down to the pipe several times each year to repair leaking joints, and the total cost of construction was less than cost of repairs during the last few years. This work was completed in May, 1915, and since that time no repairs have been necessary. The pipe passed under three main tracks so that five joints were exposed to the vibration of passing trains.

Between each line of tracks a concrete foundation was built and, resting on these foundations, reinforced concrete beams were cast, forming the walls of the culvert. At each end of the culvert, manholes were built, giving access to workmen who were engaged in repair work. The water pipe is suspended by rods fitted with turnbuckles. The total cost of the culvert was $773.

COAST TO COAST

Welland, Ont.—Work has commenced on the extension of the Niagara, Welland & Lake Erie Railway line.

Winnipeg, Man.—Further damage from electrolysis to sewers and pipes has been reported to the board of control by the city engineer's department.

Alberta Province.—In 1910 there were 1,060 miles of railway in Alberta, and in 1915 it had increased to 4,473 miles, according to figures recently issued by the government.

Kingston, Ont.—The Utilities Commission is entering into an agreement with J. M. Campbell, whereby the latter will furnish it with 300 horse-power of electrical energy from his waterfall at Kingston Mills, as auxiliary power for the Kingston steam plant.

St. John, N.B.—At a public meeting held at Armstrong's Corner, Queen's County, a resolution was passed approving of the proposal to change the route of the St. John Valley Railway from the so-called east side route, and urging that the line be constructed so as to make connection with the C.P.R. at Welsford, and thus reach St. John.

Chatham, Ont.—Building operations in this city during the three months ended March 31st show a great depreciation as compared to the same period of last year. Building permits for the past three months amount to $16,050, or $23,150 less than last year during the same period. Last month's permits amounted to $2,850, against $11,050 for last year.

Markham, Ont.—Markham village, which is installing a water system into the newly annexed suburb of Mount Joy, expects to have it completed about June 1. The work of putting down the new pipes was fairly well advanced in the fall, and the handsome steel water tower is finished. It is 160 feet high, and takes six hours to fill. It will hold 60,000 gallons, and will have a pressure of 70 pounds.

Medicine Hat, Alta.—It is reported that the cement plant south of Medicine Hat, partly completed, and which has been lying in its present state since the collapse of the building trades business some few years ago, will recommence construction. This plant was started by Leigh Hunt, of Kansas City, well known in Canadian circles, and he was employed by the Max Aiken interests to build it.

Ottawa, Ont.—On March 30th the railway committee of the Commons reported a bill extending the time for the construction of the Atlin Railway from the town of Atlin southward to the international boundary. The bill to incorporate the Edmonton and Southwestern Railway was reported. The projected line will run from Edmonton to a point on the Saskatchewan River, near Blue Rapid.

Prince Rupert, B.C.—The new floating dry dock and ship repairing plant, which the Grand Trunk Pacific Railway has built at Prince Rupert, is now open for business. The dock is in three units, with a total lifting capacity of 20,000 tons. All the units are interchangeable, and each is complete in itself. When all three are joined together the dock will be capable of raising a vessel 600 feet long of 20,000 tons. The dock has an over-all length of 604 feet 4 inches on the keel blocks, a clear width of 100 feet, and a width over all of 130 feet.

Toronto, Ont.—Seven hundred thousand dollars worth of work will be done on the new harbor development by the Toronto Harbor Commission itself this summer. The development east and west in Ashbridge's Bay and at the Humber has been almost entirely government work. This will be continued this summer, and, in addition, the Harbor Commissioners will start in on their transformation of the old harbor. The commissioners' plans provide for establishing at the foot of Bathurst Street a dock and industrial area of 17 acres north of the new channel. This area will be served with 800 feet of dock with 20 feet of water. At this point will be constructed modern freight sheds and a factory building. The proposed bulkhead line at the city waterworks dock lies 330 feet south of the new windmill line, while the proposed pierhead line is 920 feet southerly from the windmill line, the distance increasing as the line is projected easterly.

Winnipeg, Man.—With a view to providing a network of better roads all over the province, Hon. T. H. Johnson, Provincial Minister of Public Works, will appoint an organizer to form new districts throughout Manitoba in connection with the split-log drag competitions. An instructor will be named, and additional grants given. According to A. McGillivray, highways commissioner, there are only 15 districts out of 110 that have taken advantage of these competitions to date. These 15 are adjacent to Winnipeg. A new set of rules will be drawn up and more encouragement given. Municipalities desiring to take up the work in an organized manner will have the expenses in connection thereof defrayed by the government. The government will make a grant of $2.50 per mile of road entered in a competition and dragged during the entire season, besides the usual grant of $250 to the Manitoba Good Roads Association.

Regina, Sask.—Good progress is being made on the new million-dollar plant of the Imperial Oil Company now under construction in this city. One large oil tank 115 feet in diameter and 35 feet high, is just about completed, and there remains only the roof to put in place. A second large tank over 90 feet in diameter is about half completed; two 25-foot tanks are well under way, and the foundations are being laid for two additional 93-foot tanks and three 75-foot ones. These tanks are being made of steel, the material for which is shipped to Regina from Sarnia, Ont. It is ready to set in place as soon as it arrives on the grounds. One warehouse has been erected 50 ft. by 50 ft, a machine shop 25 ft. by 35 ft., and a temporary boiler house, and other small buildings. Machinery for the new plant and materials are being received almost daily. It is expected that within a short time work will commence on the permanent buildings. When completed, the plant will constitute the chief distributing centre of the Imperial Oil Company for Western Canada, covering the three provinces, Manitoba, Saskatchewan and Alberta.

AMERICAN WATERWORKS ASSOCIATION.

The thirty-sixth annual convention of the American Waterworks Association will be held in New York City, June 5th to 9th, 1916. Headquarters will be at the Hotel Astor. Overflow accommodations have been arranged for at the Woodstock Hotel, 43rd Street, east of Broadway, a short block from the Astor. The Waterworks Manufacturers' Association promises an exhibit of waterworks appliances much ahead of any previous convention. Thursday will again be set aside as superintendents' day and devoted to short practical papers by waterworks superintendents; answering questions and discussing everyday waterworks problems.

Editorial

PREPARING FOR THE FUTURE.

Sir George Foster, addressing the Toronto board of trade recently, showed, as minister of trade and commerce, a keen appreciation of the national and international trade position as it is likely to appear after the war. He predicted that unless we now plan and act for the period to follow the war, we shall pay a heavy penalty for commercial unpreparedness. He gave a clear outline of the position and the first question which must have arisen in the minds of his audience, was "What is Canada doing in this connection?"

Sir George answered this question only to an extent which would seem to show that the department of trade is hampered by politics, by lack of sufficient appropriations for the work of the department, by insufficient assistance or by other factors. The department has the proper conception of the situation but has it enough machinery for its materialization? Here we are, after nearly two years of war, listening to the first proposal of its character that an advisory council of Canada's financial, industrial, commercial and transportation leaders should be appointed to co-operate with the department of trade at Ottawa. It is an excellent suggestion and one which has constantly been made in these columns. It comes, with official backing, a year behind time, but it is a good omen. Great Britain not only appointed such a committee long ago, but the committee has met and presented a report of considerable value.

Those who heard Sir George Foster's speech, know that he is working on right lines, but is the government as a whole and the country at large giving the proper support to what is at present one of the most important departments of state, its commerce department? We think they are not.

AN ENGINEERING COUNCIL.

Mr. C. H. Rust, who was for many years city engineer of Toronto, and who has been city engineer of Victoria, B.C., for the past few years, is probably one of Canada's best-known engineers, and is a man of wide experience. It must be a great comfort to Mr. Rust, however, to have so many valued engineering assistants in the city council of Victoria this year.

Despite Mr. Rust's strong objections, the council insisted recently in calling for tenders for untreated wood paving blocks. Mr. Rust advised them that they were taking a retrograde step, not conducive to the best interests of the city, explaining that the lifetime of the treated wood block is from 50 per cent. to 75 per cent. longer than that of untreated block, and that, moreover, the treatment tends to make the block waterproof.

Mr. Rust said that the first cost of the block is not the only matter to be considered, and told of the advantages of the treated block which are so generally recognized by all engineers. Three of the aldermen, however, had ideas of their own about block paving work. One of them wished to lay a tar base, then to place the untreated block against the rails in a diagonal position, and then to cover the whole over with tar. Another alderman favored the untreated block, because he said that it would keep the moisture from sinking to the tar cushion underneath, where it would linger and perhaps disintegrate the block. The third alderman said he favored treatment in "crude oil instead of in tar."

However, we are taking a daily newspaper report as our authority concerning these suggestions of the aldermen, and perhaps we may be doing them an injustice, as daily newspaper reports on technical matters are not always absolutely correct. But if this report was correct, City Engineer Rust must certainly greatly appreciate the council's assistance. Having in their employ a man of the ability of Mr. Rust, it seems to us that the Victoria council would do well to leave purely technical matters of this sort entirely in Mr. Rust's hands.

ESCHER-WYSS FIRM INVESTIGATED.

For more than a year there has been considerable doubt as to whether or not the firm of Escher-Wyss & Co., of Zurich, Switzerland, is a German concern.

Zurich is near the German border, the firm name sounds Teutonic, the company admittedly owned a branch factory in Wurttemberg, and their managing engineer in Canada was a German subject.

Superficially the combination looked suspicious. In fact it looked so suspicious to the British War Office that many months ago the firm was put on the enemy trader list. This action brought forth strong protest from the Swiss Consul-General at London, but nothing was done pending the result of a thorough investigation into the firm's affairs by representatives of the British Government.

The directors of the firm requested full examination. They claimed that they were strictly neutral; that about as many Englishmen and Frenchmen worked at their shops as did Germans; that their stock was held in Belgium, France, England and Switzerland, as well as in Germany; that stock-control was in Switzerland and not in Germany; that the shares held by Swiss banks were not held in trust for the Allgemeine firm, as had been alleged; that the German government had taken over their Wurttemberg factory, and that they no longer had control over it; that their firm had made no munitions of war; and that since the war they had sold more goods to the countries of the Allies than they had to Germany or Austria.

These claims were fully investigated, and as a result the Canadian customs commissioner has been officially informed by London that the name of the company has been entirely removed from the Black List and that the Imperial Government is satisfied that the firm is genuinely Swiss.

The Canadian Engineer is very pleased to hear that this firm, which has done much good hydraulic and steam turbine work throughout Canada, is not an enemy trader. It may appear to them that they have not been justly treated in this country during the past year, but they must surely recognize that no part of the British Empire can afford to run the slightest risk of English money finding its way to Germany.

PERSONAL.

R. H. LEE has been offered the position of city engineer at Kamloops, B.C.

A. T. ARNOLD has been appointed supervisor of public works at Chatham, Ont.

D. ANSCOLD, for eleven years road superintendent of North Vancouver, B.C., has resigned.

J. D. McMILLAN has been appointed acting superintendent of Districts 5 to 10, Belleville Division, Grand Trunk Railway.

T. C. DUNCAN, for three years superintendent of the light and telephone department at Prince Rupert, B.C., has resigned.

H. M. WILLIAMS has been appointed head of the publicity department of the Montreal Light, Heat and Power Company, with offices at 301 Power Building, Montreal.

J. W. ADAMS has been appointed city engineer of Chatham, Ont., to succeed his brother, F. P. Adams, who has been granted leave of absence, and has enlisted for overseas service.

ALONZO B. SEE, president of the A. B. See Electric Elevator Co., Montreal and New York, has been elected vice-president of the Machinery Club of New York City, to succeed the late John A. Hill, publisher of the American Machinist.

N. BRUCE McKELVIE, of the firm of Hayden & Stone, Boston and New York, has been appointed a director of the Nova Scotia Steel & Coal Co., Halifax, N.S. Mr. McKelvie is a native of Prince Edward Island. This appointment completes the board of directors.

JOHN D. McBEATH, C.E., of Moncton, N.B., has been given a commission with the Canadian Engineers for overseas service. Mr. McBeath is a graduate of the University of New Brunswick, and was for a time assistant engineer in Moncton and later assistant engineer in Medicine Hat, returning to Moncton last spring.

A. E. WRIGHT, of the Dominion Steel Foundries, Hamilton, Ont., has been promoted to the position of secretary-treasurer, and FRED W. SHERMAN will assume the duties of purchasing agent. MR. HAMMON, who was formerly secretary-treasurer, has severed his connection with the company, and has taken up his residence in California.

Ex-Alderman GEORGE McKNIGHT has been appointed city engineer of Fredericton, N.B., and will take over his new duties about April 15th. At present Mr. McKnight is engaged as an engineer with the St. John and Quebec Railway Company, having been engaged in the construction work on the St. John Valley Railway from the start of that project.

W. H. ROBINSON, of Granby, Que., has been elected president of the Canadian Consolidated Rubber Company, Limited, Montreal, to succeed Mr. J. H. McKechnie, deceased. Mr. Robinson is already identified with a number of large corporations, being vice-president of the Granby Consolidated Mining & Smelting Company, and a director of the Crow's Nest Pass Coal Company.

NORMAN K. HAY, city engineer of Sydney, N.S., has enlisted for overseas service in the 224th (forestry) battalion, and has been granted leave of absence while at the front. Mr. Hay was graduated from McGill University in 1907 and went to Sydney the same year. He took a position at the street works as street engineer under W. C. Risley and remained there until June, 1913, when he became city engineer. Private Hay is a native of Ottawa.

OBITUARY.

HENRY HARTUNG, a well-known sewer contractor, died recently at his home in Hamilton, Ont., at the age of 51.

GEORGE P. BRECKON, head of the firm of G. P. Breckon & Co., sheet metal workers, Toronto, Ont., died suddenly at his plant on March 30th.

WILLIAM E. MANN, M.Can.Soc.C.E., died as the result of having fallen down the elevator shaft in the Alberta Hotel, Edmonton, Alta., March 29, 1916. Mr. Mann was at one time division engineer for the Grand Trunk Pacific Railway, and was a member of the Edmonton branch of the Canadian Society of Civil Engineers.

H. N. DANCY, president and managing director of H. N. Dancy & Son, Limited, mason contractors, and for upwards of half a century a resident of Toronto, died in this city recently. Mr. Dancy was born in Ditchling, Sussex, England, in 1846. Among other large buildings erected under his supervision were the new Wycliffe College, General Hospital, Administration Building and Knox College.

LUNCHEON OF TORONTO BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Toronto branch of the Canadian Society of Civil Engineers proposes holding a luncheon at the St. Charles Hotel, Toronto, on Thursday, April 27th, at 1 p.m. It is hoped that sufficient attendance will be warranted to justify the securing of a good speaker for this occasion. We would, therefore, urge upon all members of the branch who can possibly do so to make it their business to attend this luncheon as undoubtedly it will be a pleasant and profitable occasion.

The secretary of the branch, L. M. Arkley, asks that members ascertain as fully as possible the names and standing of as many prospective members as possible in the vicinity of Toronto. Co-operation on the part of each member in this matter would be heartily appreciated by the executive.

ONTARIO HEALTH OFFICERS' ASSOCIATION.

T. Chalkley Hatton, chief engineer of the Sewerage Commission, Milwaukee, Wis., is to deliver a paper on "The Treatment of Sewage by Activated Sludge," at the meeting of the Ontario Health Officers' Association, to be held in Convocation Hall, University of Toronto, May 30th and 31st, 1916.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

REMOVAL NOTICE.

The British American Oil Co., Limited, has moved its head office at Toronto from the Lumsden Building to the Royal Bank Building, corner King and Yonge Streets.

Volume 30. Toronto, April 20, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

PRECISE LEVELLING BY THE GEODETIC SURVEY

A REVIEW OF THE WORK BEING DONE BY THE GEODETIC SURVEY OF CANADA IN MAKING A PRECISE SYSTEM OF LEVELS.

By F. B. REID, D.L.S., Supervisor of Levelling.

LEVELLING may be defined as the art of determining the relative heights of points on the earth's surface. Precise levelling differs from ordinary levelling in several respects, both as to the instruments used and the field methods employed; finer materials and workmanship enter into the construction of the instruments and special precautions are taken in the field to avoid the accumulation of errors on long lines. One of the most important precautions is the system of duplicate levelling—all work being run at least twice, in opposite directions. To anyone familiar with the practice of ordinary levelling various other differences in procedure will reveal themselves during the course of this paper.

The value to any country of a system of levels of high precision is unquestionable. The exploratory and other preliminary work in connection with engineering projects such as railways, canals, highways, water supply and irrigation systems, etc., is much facilitated by having accurately determined bench marks to connect with at short intervals and is still further facilitated by the use of contour maps of the country, these having been prepared with a line or a net of precise levels as the basis. In this connection it is interesting to note that the Public Works Department, at the time of making the surveys for the proposed Georgian Bay Ship Canal, found it necessary several years ago to run a line of precise levels from Rouse Point, N.Y., to North Bay, Ont., via Vaudreuil and Ottawa, checking this by means of water transfers across Lake Ontario and a line of precise levels from Toronto to North Bay. Again, it is significant that at least two of the leading American railroads—the Pennsylvania and the Baltimore and Ohio—have carried out precise levelling operations of considerable magnitude at their own expense.

Judging from all the above that the work is of considerable practical value to the public at large, let us turn for a moment to its usefulness in connection with the

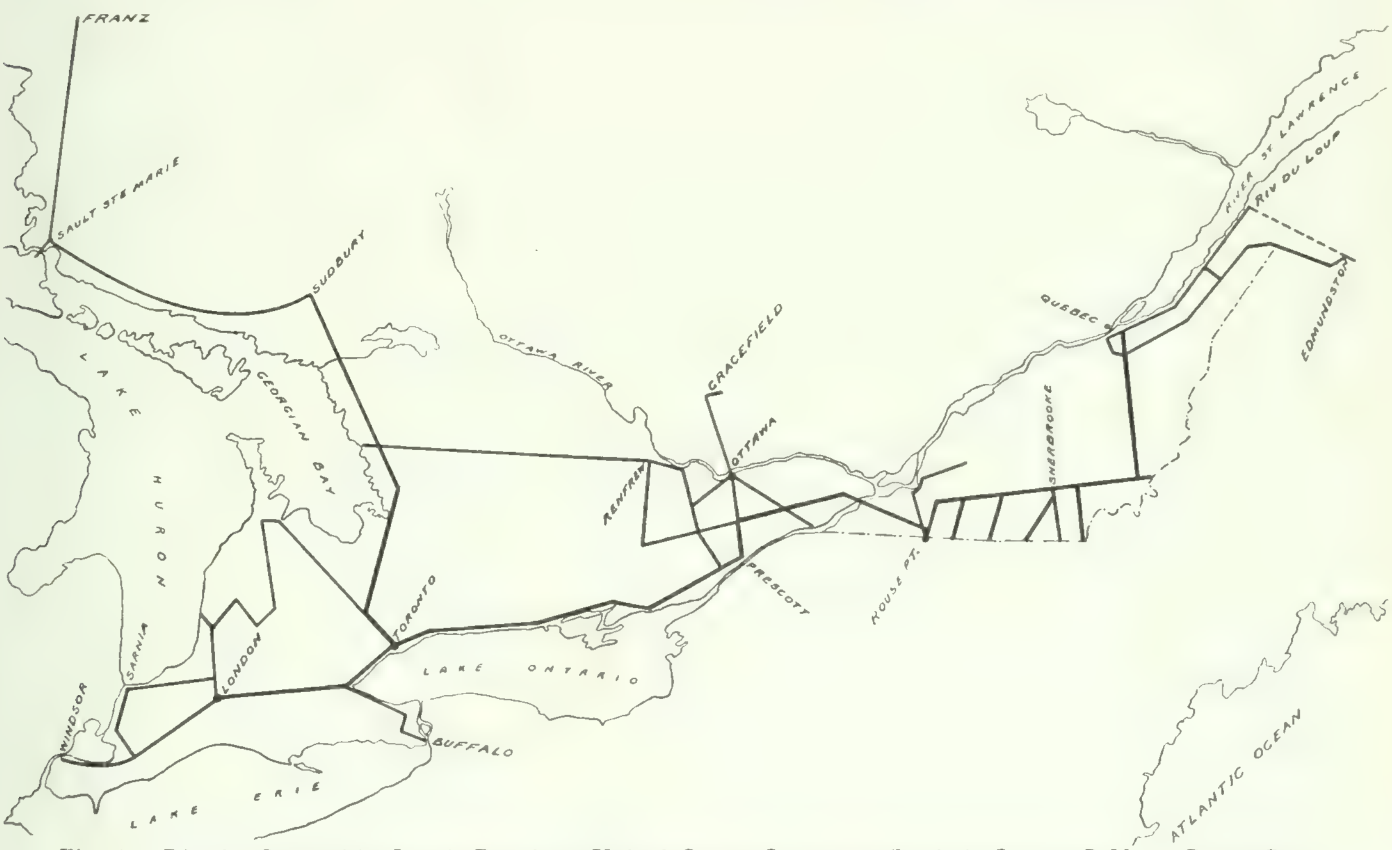


Fig. 1.—District Covered by Levels Run from United States Coast and Geodetic Survey B.M. at Rouse Point.

various topographical surveys carried on by the Militia and other Government Departments, the International Boundary Survey and the triangulation branch of the Geodetic Survey. J. B. Johnson, in his manual of surveying, has the following to say on this latter phase of the subject: "In order that triangulation distances may be reduced to sea-level, the elevations of the bases at least must be found. It is impossible to carry elevations accurately from one triangulation station to another by means of the vertical angles, on account of the great variations in the refraction. Barometric determinations of heights are also subject to great uncertainties unless observations be made for long periods. The only accurate method of finding the elevations of points in the interior above sea-level is by first finding what mean sea-level is at a given point, by means of automatic tide-gauge records, for several years, and then running a line of precise spirit levels from this gauge inland and connecting with the points whose elevations are required. Most European countries have inaugurated such systems of geodetic levelling, this work being considered an integral part of the trigonometrical survey of those countries."

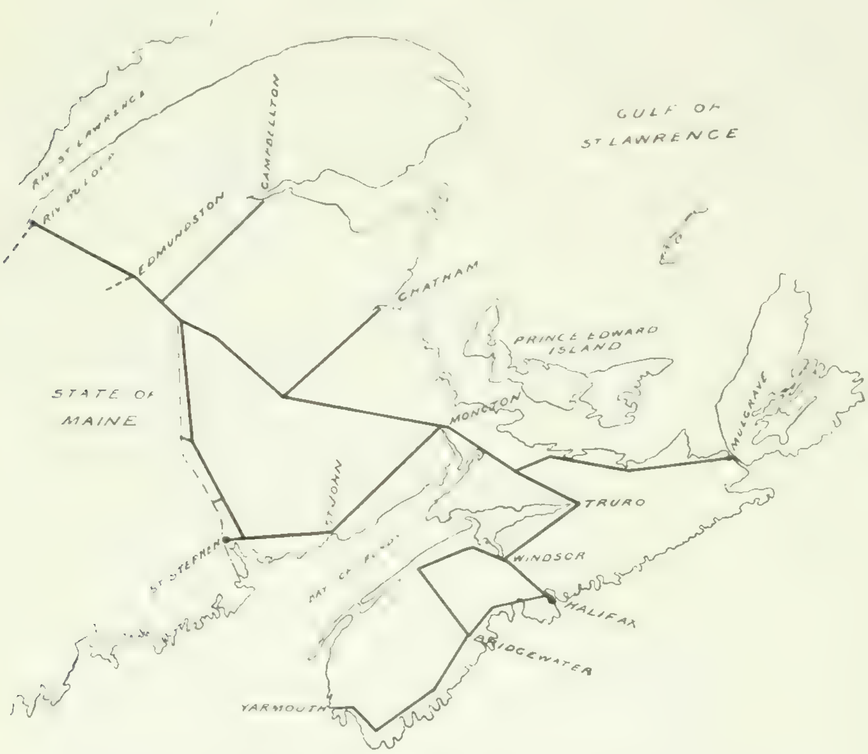


Fig. 2.—District Covered by Levels Run from B.M. at St. Stephen, N.B., Established in 1873 by the U.S. Corps of Engineers, and from Mean Sea-Level as Established by the Tidal Survey at Halifax, N.S.

Precise levelling is, whenever possible, carried along railway tracks, rather than along highways or across country, the advantages of this practice being many. The rate of rise and fall of the track is usually fairly uniform and no steep hills are encountered, thus allowing longer average sights to be taken and allowing the backsights and foresights to be easily kept of equal length. The rails furnish excellent supports for the levelling rods and thus the time is saved which would otherwise be consumed in putting artificial turning points into the ground. The masonry structures—bridges and culverts—situated along the railways are utilized for placing permanent benchmarks; this is of advantage both to us and to the railway companies. Again, the use of a hand-car for going to and from work and for moving along from point to point during the day, effects a large saving of time and labor, and the transportation of the camping outfit from camp to camp by freight is cheaper and more convenient than the method by horse and wagon. Against these and other advantages may be set the fact that the refraction and boiling of the atmosphere caused by the sun is considerably greater on a railway track, owing to its exposed character and the materials of which it is constructed.

Datum Planes and Territory Covered.—Geodetic levelling is always based upon mean sea-level as a datum, mean sea-level being assumed to be everywhere the same except insofar as it may be affected by the irregularities of the coast line, as, for instance, in land-locked bays or the estuaries of rivers in which the free entry and exit of the tide may be obstructed. Automatic self-registering tide gauges have been established and are maintained by the Tidal and Current Survey, Department of the Naval Service, at various points on the Atlantic and Pacific coasts; regarding the determination of mean sea-level by the aid of these gauges the superintendent of the survey, Dr. Dawson, has made the following statement: "The value of mean sea-level is found in the first place for a period of one continuous year at a time. It is based upon the height of the tide at every hour (day and night) taken from the autograph record of the tide gauge. By comparison with direct observations for time and height, the record from the registering gauge is reduced to a truly uniform datum from year to year, with relation to a bench mark. The value of mean sea-level in each year is thus the average of 8,760 individual measurements at successive hours without a break. If any serious interruption occurs, a fresh beginning is made. The basis for the final determination is in all cases a series of complete years of this character; and such determinations have evidently a very high accuracy."

The levelling of the Geodetic Survey has been started from five bench marks or reference points, in widely separated parts of the country, each one being connected—more or less directly—with mean sea-level. The first levelling was started from the United States Coast and Geodetic Survey bench mark at Rouse Point, N.Y., and two lines have been extended from this point, one easterly through Megantic and Levis to Edmundston, N.B., and Riviere du Loup, Que., with several branches to the international boundary, and the other westerly to Ottawa, Toronto and Windsor, also northerly to Sudbury and Sault Ste. Marie; at the end of last season this line had been extended 200 miles north of the Soo to Franz, the junction of the Algoma Central Railway with the main line of the C.P.R.; 3,370 miles of levelling are included in this district. The second initial-point was a bench mark at St. Stephen, N.B., whose elevation had been established by the United States Corps of Engineers in 1873; from this our levels have been carried northerly to Riviere du Loup, Que., and easterly to Moncton, N.B., the total amount of levelling, including cross lines and branches, being 1,022 miles. The initial-point for the third district was the automatic tide gauge at Halifax, mean sea-level at this point having been established by the Tidal Survey from their records extending over nine complete years. Two main lines of levelling

have been run from Halifax, one extending to Yarmouth, the other to Moncton, the total amount of levelling included in this district being 592 miles. It is satisfactory to be able to state that the two elevations of the junction bench mark at Moncton, as derived from the St. Stephen datum and from the Halifax datum, differ by only two-tenths of a foot. The two elevations of the junction bench mark at Riviere du Loup, as derived from the St. Stephen datum and from the Rouse Point datum, differ by a little over four-tenths of a foot.

The initial-point for the fourth district was the United States Coast and Geodetic Survey bench mark at Stephen, Minn. To utilize this we were obliged to run 45 miles of levels through Minnesota to the international boundary at Emerson, directly south of Winnipeg. From Emerson one line was extended easterly to Port Arthur, the other westerly to Regina, Prince Albert, Edmonton, Calgary, etc. Last summer this line was carried west from Calgary over the summit of the Rocky and Selkirk mountains and was discontinued for the season near Revelstoke, B.C.; 3,279 miles of levelling are included in this district. The initial-point for the fifth district was the automatic tide gauge at Vancouver, mean sea-level at this point having been established by the Tidal Survey from their records extending over seven complete years. Levels from Vancouver extend southerly to the international boundary at two points and also easterly a comparatively short distance; 142 miles of levelling are included in this district.

From the above summary it will be seen that a transcontinental line has been almost completed, only two gaps in the line now remaining, one between Franz and Port Arthur and the other between Revelstoke and the end of the Vancouver line, the length of the gap, by a coincidence, being about 295 miles in each case. It is confidently expected that these will both be filled in during the coming season and we shall then have an unbroken line of precise levels connecting the tide gauge at Halifax with the tide gauge at Vancouver. This line is rapidly being paralleled by a second and in some cases by a third line where this is considered advisable.

Criticism has come from some quarters because the levels have been based partly upon intermediate points like Rouse Point, N.Y., and Stephen, Minn., instead of entirely upon the tide gauges on the sea coasts. At least two answers may be made to this: firstly, when the work was in a more or less experimental stage and the staff was inexperienced it would not have been advisable to conduct the levelling at such a great distance from headquarters; secondly (and more important), the results were required for the use of the International Boundary Surveyors and others, and with the limited organization then available it would have taken a very considerable period of time to carry levels from the Atlantic coast to the Quebec-Vermont boundary, for instance, or from the Pacific coast to the provinces of Saskatchewan and Manitoba.

Instruments.—The instrument adopted is a precise level of the United States Coast and Geodetic Survey pattern.

Great care has been expended on the construction of the rods used upon this work. They are built up of three pieces of white pine, giving a cross-section in the form of a symmetrical cross, this form having been found to offer the greatest resistance to bending and warping. They are boiled thoroughly in paraffin which tends to keep them of constant length under varying conditions of atmosphere and temperature. Silver plugs are inserted in the face of the rod approximately at the three, six and nine-foot points, and the exact positions of these points marked by a fine scratch on the face of the plug; the rod is then subdivided into feet, tenths and hundredths in alternate white and black spaces of one one-hundredth of a foot. When observing the rod the readings are made to thousandths, the hundredth spaces being subdivided by estimation. As it is impossible to subdivide a black space accurately at the distance the rod is usually observed, two sets of graduations are placed, side by side, one on each side of the centre line of the rod, the white spaces of one adjoining the black spaces of the other; thus the observer has always a white space to subdivide by reading on the right-hand or the left-hand set of graduation marks, as the case may be. The bottom of the rod is encased in a brass shoe which is fitted underneath with a hemispherical knob of steel; this is specially suitable for holding on a

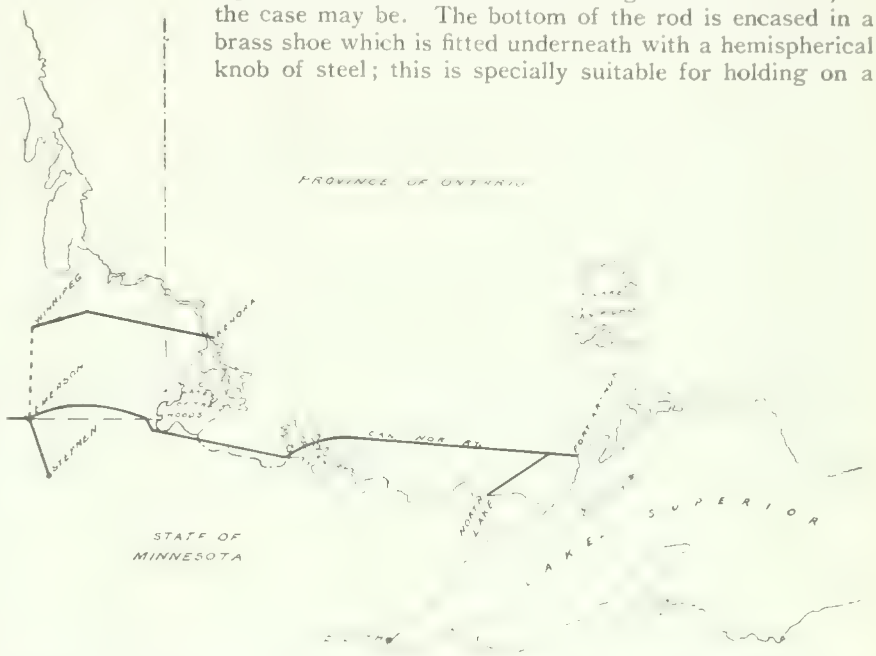


Fig. 3.—District Covered by Levels Run from the B.M. Established by the United States Coast and Geodetic Survey at Stephen, Minn.

flat surface such as the top of the rail of a railway track.

Another piece of apparatus which is very necessary is a large carriage umbrella with a handle about 8 feet long, provided with a spike at the end to insert in the ground. The umbrella is used whenever the sun is shining while observations are in progress, to shade the instrument from its rays; without this the parts would become unequally heated and irregular and unreliable action of the bubble would follow.

While carrying the instrument between sights a cover of duck or cravenette is used for the same purpose; this also is used to protect it when working during a light rain. In a heavy rain the work has to be discontinued.

Field Methods.—The standard bench mark established by the Geodetic Survey consists of a copper bolt ¾ inch in diameter and 4 inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench Mark). The bolt is sunk horizontally in rock or masonry, a hole being drilled of the exact size of the bolt or a shade larger and the latter hammered till it completely fills the hole, the end being flush with the surface of the masonry or projecting slightly. Properly put in, it is impossible for anyone to remove it without destroying the

surrounding rock or masonry. After the exposed end has been planed to a smooth surface by means of a file, it is stamped with a steel die containing the above-mentioned letters. Then, by means of a cold chisel, a horizontal cross mark is made, upon which the elevation is taken; finally the number is stamped with other steel dies. Elevations are not marked on because the elevation of a bench mark is a precise levelling net may not be finally decided upon for a long time. The closing of circuits and introduction of new cross lines will call for adjustments which will make changes of greater or less magnitude in the elevations. Also, the computation of the elevations from the field notes is a work of some magnitude and would delay the operations of the parties were it performed in the field. It is, therefore, left to be done in the office after the notes have been carefully checked. I might say, also, that an engineer would not usually attempt to look for the bench marks haphazard, but would set out armed with descriptions of their locations.

Levellers are instructed to aim at getting bench marks at intervals of about three miles when suitable locations which may be encountered en route. Engineers are thus enabled, if they wish, to reduce their elevations to our precise datum without any additional field work on their part.

A precise levelling party consists of seven men, the chief or leveller, recorder, two rodmen, umbrellaman, cook and a railway employee, usually a section man, to pilot the hand-car. Camps are made at the stations along the line, the distance apart varying from 10 to 20 miles. The levelling is carried continuously forward, day by day, through the camp and to a point about half-way to where the next camp ahead will be.

General instructions issued to levellers are: "All lines are to be levelled twice, in opposite directions, called forward and backward levelling. Backward shall in every respect be independent of forward levelling and the same turning points shall not be used. If the forward levelling is made in the forenoon, the backward—over the same section—should be made in the afternoon, it being desirable to secure as much difference in atmospheric conditions between the forward and backward measurements

Fig. 4.—District Covered by Levels Run from B.M. of the United States Coast and Geodetic Survey at Stephen, Minn.

can be found, and in no case to run more than eight miles without establishing one. To comply with the latter requirement it has been found necessary to erect, at certain points, concrete piers, specially for bench marks. These piers are 6 feet 3 inches high, 9 inches square at the top and 15 inches square at the bottom, resting on a concrete footing. The whole pier is buried to within about 9 inches of the top, and the copper bolt built in, near the ground surface, having been previously stamped and numbered. The piers are usually built on the railway right-of-way, within 3 or 4 feet of one of the fences and on fairly level ground, where they will not be exposed to danger from future alterations in the railway grade.

Temporary bench marks are placed at intervals of 1 mile or thereabouts. They consist usually of spikes, driven horizontally into telegraph poles, and, as their designation implies, they are used only for convenience while the work is progressing. They are not embodied in the final records.

Besides establishing our own bench marks as above described, it is our practice to connect with any permanent or semi-permanent bench marks of other organizations as is possible without materially delaying the work for this purpose.

"Other things being equal, it is considered better practice to complete all forward levelling to be done at one camp before making any backward measurements, rather than to run a few sections forward and then backward and repeat this process two or three times before moving camp.

(Read before the Royal Astronomical Society of Canada, at Ottawa, March 31, 1916.)

(To be continued.)

Satisfactory accounts have been received of the performance of the ice-cutting car-ferry Leonard which was built by Messrs. Cammell, Laird and Company to convey the National Transcontinental Railway Company's trains across the St. Lawrence from Quebec to Point Levis. Since her first trip in May last the vessel has transferred as many as 90 cars in a single day. The trains are carried on a tidal or upper deck, which has three lengths of track, 272 ft. long and each able to hold three passenger coaches. The vessel has three sets of triple expansion engines, two being for propulsion, while the third drives the ice-cutting propeller, which is fitted at the bow.

SOOKE LAKE PIPE LINE SUCCESSFULLY OPERATES THROUGH A HARD WINTER.

THIS pipe line was built in order to utilize Sooke Lake as a water supply for Victoria, B.C. The contract for the construction of the line was awarded to the Pacific Lock Joint Pipe Company, and the contractors, having the necessary forms on hand for a 42-inch pipe, agreed to put in a 42-inch pipe instead of a 40-inch pipe, as had been suggested by the engineers. The pipe was made of a shell 3 inches in thickness and in 4-foot lengths, except the pipe for syphons, which was more heavily reinforced, the shell being 4 inches thick.

In *The Canadian Engineer* for November 18th, 1915, there was published an illustrated description of the above work as presented before the American Society of Municipal Improvements by Mr. C. H. Rust, the city engineer and water commissioner of Victoria, B.C.

As a piece of municipal engineering work, this job attracted a great amount of attention, and for this reason

Fig. 1.—Circuitous Route followed Owing to the Rough Nature of the Ground.

we feel that it would be desirable to recapitulate some of the details of this plant, and also to give further information which has been supplied to us by Mr. Rust, this information being of particular interest as it has been secured after the work has successfully weathered the winter storms and the particularly cold temperature which prevailed on the Pacific Coast last winter. After nine months of operation the Sooke Lake pipe line emerges victoriously in that no material damage has been done during its first months of actual operation. This is all the more remarkable when it is stated that Vancouver Island has, during the past winter, experienced the coldest weather it has ever known, so far as the recollection of the oldest inhabitant goes. It went as low as 12° below freezing. Luckily, however, the snow was excessive, which probably protected some of the work to a greater or lesser extent.

Owing to the deep snow it was difficult for the patrol men to keep up communication and they suffered a good deal of hardship in getting in supplies. The only damage done to the pipe was occasioned by a small slide which, however, was not serious. Nearly the whole length of

Fig. 2.—Construction Railway Trestle and Syphon Over Ravine.

the pipe, which is 27½ miles long, is laid on the side of a mountain and of the total length of pipe 55 per cent. is in curve; the longest tangent being 600 feet. This will give some idea of the difficulty of the construction work, not only from the point of view of alignment, but from the point of view of the contractor, who had to transport

Fig. 3.—View Showing Rough Nature of Ground Over which Pipe Line was Constructed.

material to all parts of the line. A road-bed 8 feet wide was constructed for the pipe, which was built as a flow line conduit. The construction of this road-bed necessitated the removal of about 270,000 cubic yards of material, over half of which was rock. This rock was hard trap except in the 2½-mile section near Sooke Lake,

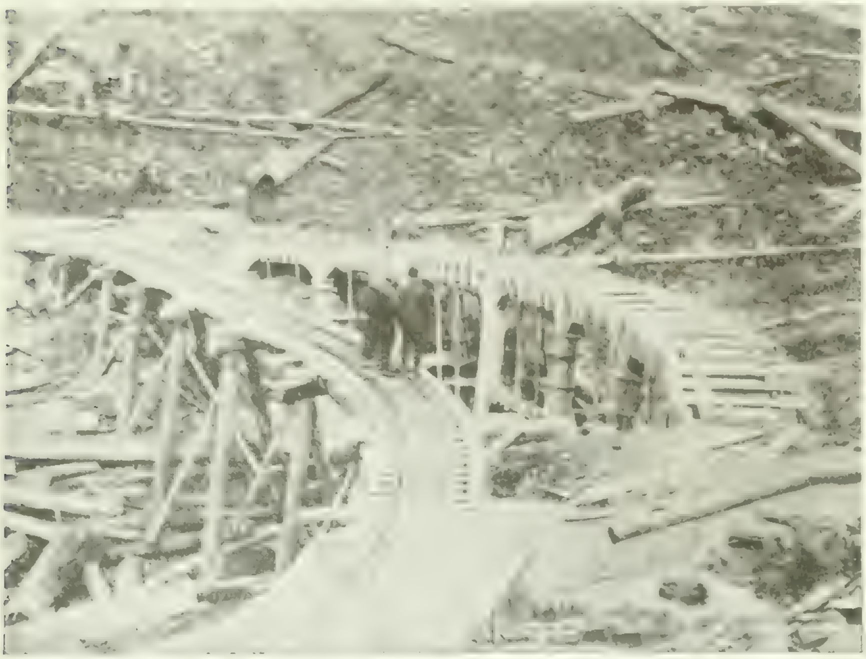


Fig. 4.—View Showing Timber Trestle of Construction Railway and Concrete Trestle for the Pipe Line.

which was schistose. This latter part of the pipe line was covered, as slides were feared. The remainder of the line was left uncovered.

In order to facilitate the work, a narrow-gauge construction railway was built paralleling for the most part the line of the concrete pipe. This was built to flow line grade, temporary log trestles being built over ravines which the pipe line syphoned across. The deepest syphon is 600 feet long and has a head of 90 feet operating. The general grade of the flow line is one in a thousand.

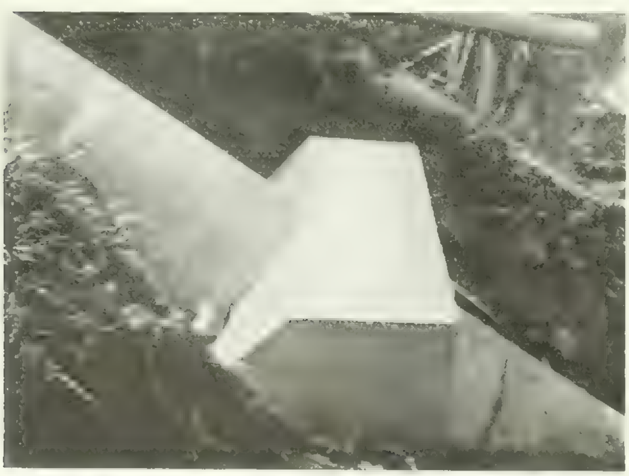


Fig. 5.—Concrete Anchor in a Syphon Section of the Pipe Line.

Particular attention was paid to this railway, the trestles of which were built of the available timber in the locality. Water barrels were installed on the trestles for fire protection. The road-bed in all other places was rock ballasted. The rails used were 20 pounds and were laid on split ties of Douglas fir. Wherever it was deemed necessary for the expedition of the work, side tracks were cut in.

As fast as the railway was available for operation the concrete aggregate, reinforcing, timber, etc., were hauled out and permanent structures started. The concrete trestles, which were generally located on sharp curves, were the chief item.

The pipe, which was manufactured at Cooper's Cove, has been described in these columns before. It was delivered to all parts of the work by the railway. It was found that when pipe had been properly covered there was no danger of it being damaged in transit, and no precautions out of the ordinary were taken to protect the pipe. On the syphons large concrete anchors were cast around the pipe, as shown in the accompanying photograph. At the bottom of the valleys, which were syphoned over, the pipe was laid on concrete trestles and a clear waterway left for floods beneath the pipe. No particular difficulty was experienced in laying the pipe, which was done with a pipe tripod and chainblock, an overhead trolley system proving a failure owing to the crookedness of the lines.

The pipe has withstood the ravages of winter well; no very large leaks developing. It is noteworthy that the specifications for the pipe did not require that the pipe should be absolutely watertight. The specifications stated that "the pipe shall be considered tight, provided that the accumulated leakage at any place does not show greater than as continuous drops leaving the outside surfaces of the pipe at any point. The Pacific Lock Joint Pipe Company, who supplied the concrete pipe and guaranteed it for one year, are repairing the few small leaks which have developed during the winter.

RAILROAD EARNINGS.

The following are the weekly railway earnings for March:—

Canadian Pacific Railway.

	1916.	1915.	
March 7	$2,198,000	$1,667,000	+ $531,000
March 14	2,258,000	1,731,000	+ 527,000
March 21	2,281,000	1,738,000	+ 543,000
March 31	3,491,000	2,564,000	+ 927,000

Grand Trunk Railway.

March 7	$ 992,026	$ 852,151	+ $139,875
March 14	957,542	857,147	+ 100,395
March 21	967,233	857,937	+ 109,296
March 31	1,592,442	1,346,969	+ 145,473

Canadian Northern Railway.

March 7	$ 540,200	$ 428,700	+ $111,500
March 14	538,000	412,000	+ 126,000
March 21	549,000	421,700	+ 127,300
March 31	979,800	637,000	+ 342,800

The following are the railroad earnings for the first week of April:—

Canadian Pacific Railway.

	1916.	1915.	
April 7	$2,482,000	$1,766,000	+ $716,000

Grand Trunk Railway.

April 7	$1,155,486	$1,008,320	+ $147,166

Canadian Northern Railway.

April 7	$ 677,000	$ 457,000	+ $220,000

GRAPHICAL TREATMENT OF ELASTIC RIBS.

I. BEAMS.

THE deflection of curved or straight beams or arch ribs can easily be determined analytically, according to C. S. Whitney, M.C.E., in "The Cornell Civil Engineer," by the use of the calculus for very simple cases, but where the shape of the rib is irregular or the moment of inertia is variable so that it cannot be expressed by a simple equation the treatment becomes

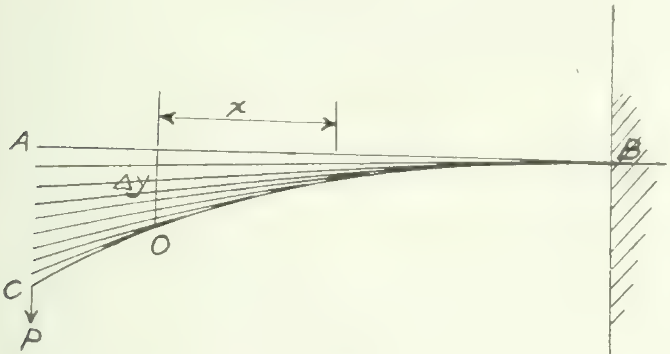


Fig. 1.

quite difficult. By the remarkably simple method explained below it is possible to draw to scale the elastic curve for any rib or beam under any load in a very short time. The method seems to be practically unknown in this country, and although it is original with the writer method here outlined in combination with the theory of virtual displacements affords the simplest of all methods of analyzing such structures as continuous beams, two-hinged arches, or fixed reinforced concrete arches. Asymmetry or irregularity of section does not affect the ease of solution. Results can be obtained by the graphical method with any degree of accuracy which may be warranted by practical considerations.

The deflections are obtained by the graphical integration of the familiar equations

$$\Delta x = \int \frac{M y\, ds}{E I}, \quad \Delta y = \int \frac{M x\, ds}{E I}, \text{ and } \Delta \phi = \int \frac{M\, ds}{E I},$$

the derivation of which may be found in Church's "Mechanics of Engineering" and other texts. It must be noted that the integration is from the point of which the displacements are to be obtained to the point where the rib is considered fixed and the displacements secured are relative to the tangent and normal at the point considered fixed.

In the case of the simple straight cantilever (Fig. 1) the y displacement, Δy, of any point O relative to the tangent AB is equal to $\int_0^B \frac{M x\, ds}{E I}$ or if the beam be divided into small Δ s's the value of Δy is approximately $\sum_0^B \frac{M x \Delta s}{E I}$. If the value of $\frac{\Delta s}{E I}$ be made a constant, then

$$\Delta y = \frac{\Delta s}{E I} \sum_0^B M x \quad - \quad - \text{ Eq. 1.}$$

The simplicity of this equation suggests a graphical summation which may be accomplished by means of the force polygon and funicular polygon, as shown in Fig. 2.

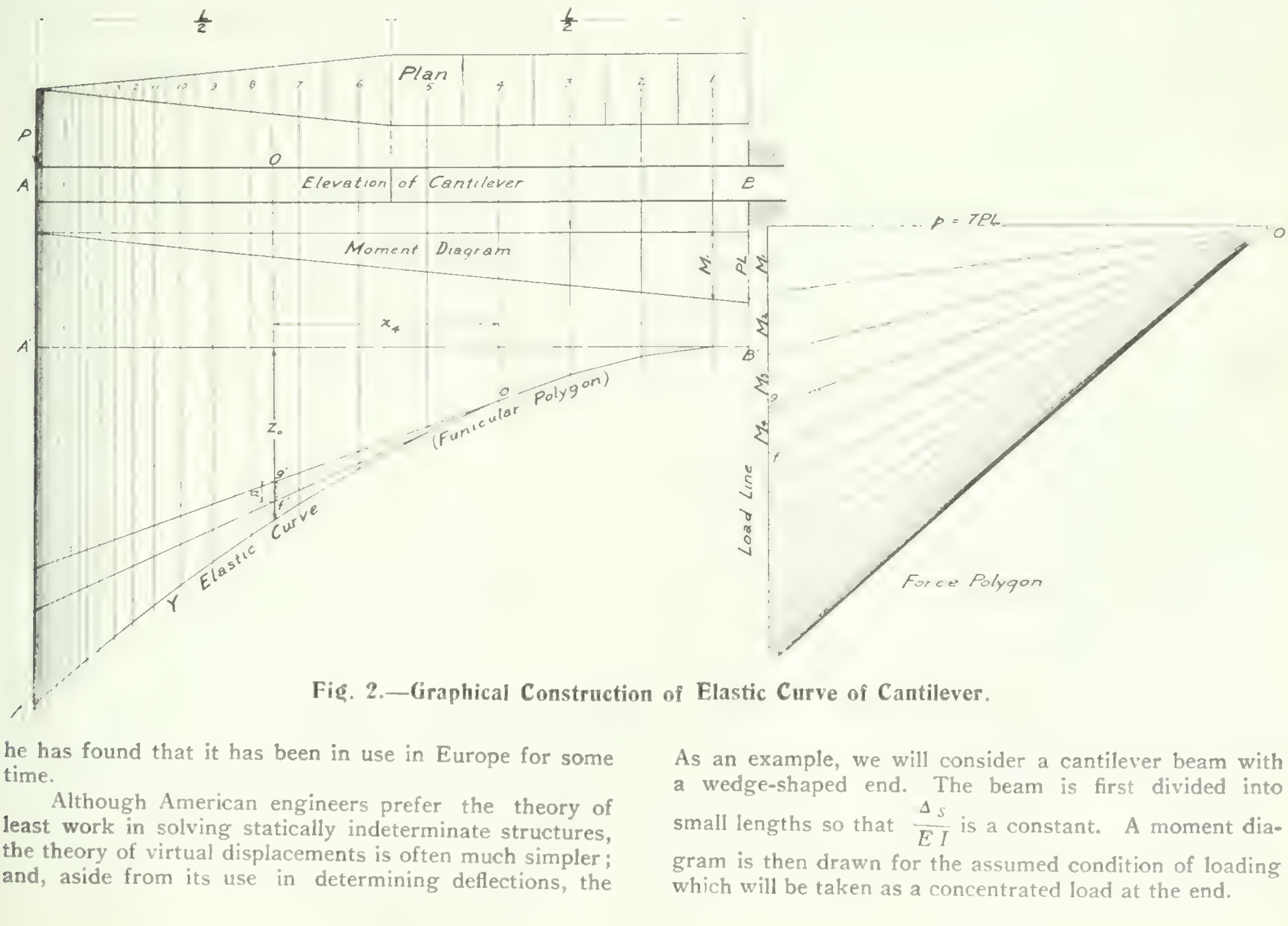


Fig. 2.—Graphical Construction of Elastic Curve of Cantilever.

he has found that it has been in use in Europe for some time.

Although American engineers prefer the theory of least work in solving statically indeterminate structures, the theory of virtual displacements is often much simpler; and, aside from its use in determining deflections, the

As an example, we will consider a cantilever beam with a wedge-shaped end. The beam is first divided into small lengths so that $\frac{\Delta s}{E I}$ is a constant. A moment diagram is then drawn for the assumed condition of loading which will be taken as a concentrated load at the end.

The centres of the different divisions of the beam are projected down through the moment diagram and the corresponding moments are laid off algebraically in order on the load line of the force polygon. A pole is then chosen at any convenient distance, p, from the load line and the rays are drawn. The funicular polygon $A''B'$ is drawn with its sides parallel to the rays of the force polygon just as though the moments were forces acting at the centres of gravity of the division of the beam. A consideration of the geometry of the two figures will show at once that the ordinate z_0 is equal to $\sum_0^1 Mx$ divided by p, that is $\sum_0^1 Mx = pz_0$. This may be seen from the two shaded triangles Ofg and $o'f'g'$ which are similar because their sides were made parallel. $M_4 : a = p : x_4$ or $a = \frac{M_4 x_4}{p}$. The ordinate z_0 is therefore equal to the summation of the values of $\frac{Mx}{p}$ from O to B. Since this relation is true for any point, a curve drawn tangent to the funicular polygon is the elastic curve itself and the deflection of the beam at any point is given by the expression

$$d_0 = \Delta_0 y = pz_0 \frac{\Delta x}{EI}.$$

The value of p is measured by the scale of the load line of the force polygon and z_0 by the scale of the beam diagram AB. From Fig. 2 the following results were obtained:

$$z_A = A''A' = .506L$$

$$d_A = 7\,PL \times .506L \times \frac{\Delta x}{EI}$$

$$\frac{\Delta x}{EI} = \frac{L}{10\,EI_B}$$

$$d_A = \frac{3.542\,PL^3}{10\,EI_B} = 0.3542\,\frac{PL^3}{EI_B}$$

Church's "Mechanics of Internal Work" gives the value $.3540 \frac{PL^3}{EI_B}$ for the deflection of the same beam. Eighteen or twenty divisions of the beam or rib are enough for ordinary cases and the scale need not be made large to bring the error within one or two per cent.

Exactly the same method may be applied to ribs with curved or polygonal axes. The moments for any loading are laid off algebraically on the load line and the funicular polygon is constructed on the lines formed by projecting down the centres of the divisions of the rib. The curve obtained is, of course, only the curve of the y displacements.

It must be apparent that the x-displacements may be obtained in exactly the same manner by projecting the centre points horizontally and constructing a funicular polygon with sides perpendicular to the rays of the force polygon used for the y-displacements. The application to curved arched ribs will be shown in another article.

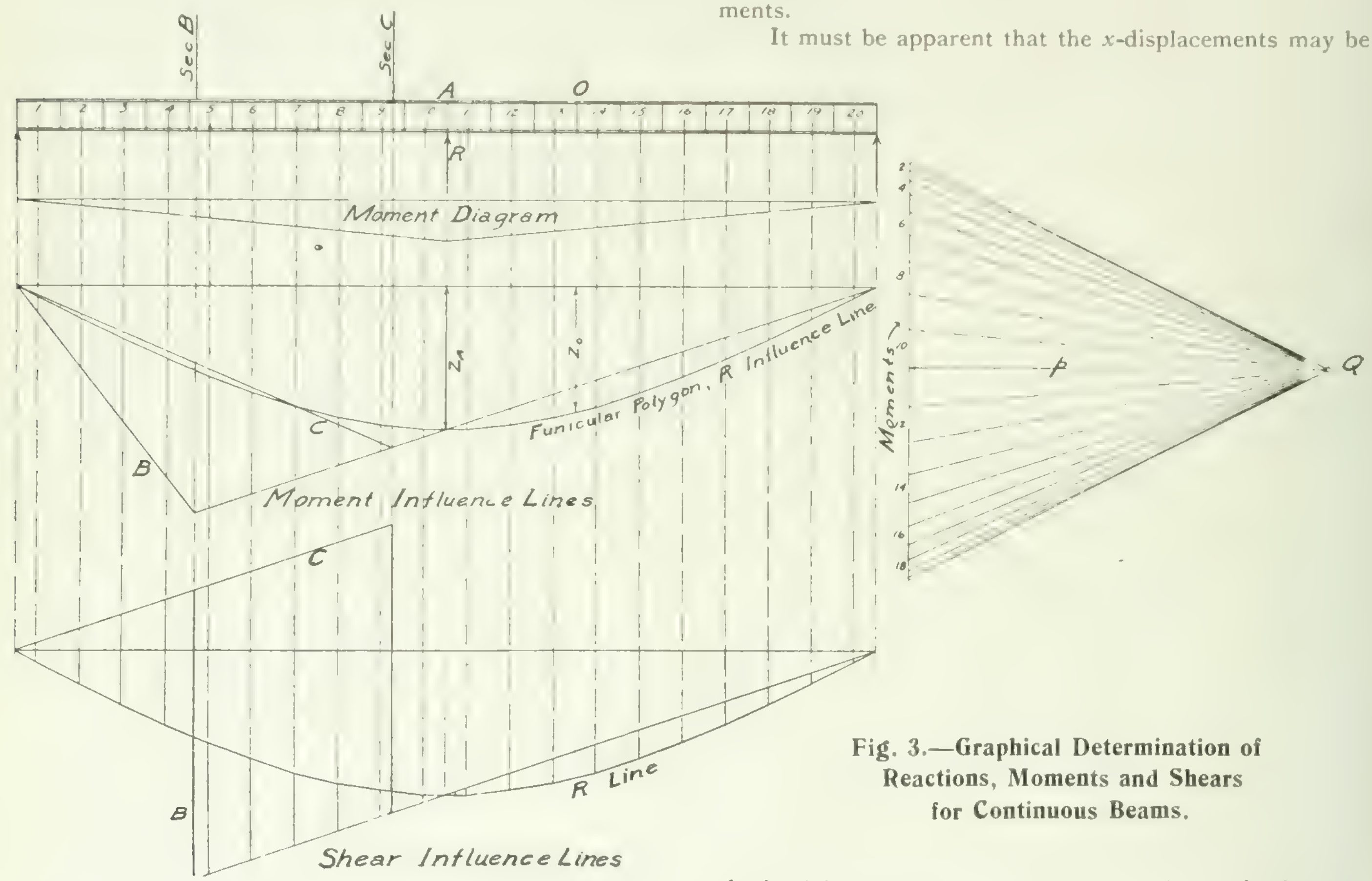


Fig. 3.—Graphical Determination of Reactions, Moments and Shears for Continuous Beams.

This simple method of determining displacements may be used to great advantage in analyzing statically indeterminate ribs or beams. It is used as a means of applying the theory of virtual displacements, and Maxwell's Theorem of reciprocal displacements is also employed.

A statically indeterminate frame may be considered as a statically determinate frame with certain redundant forces acting on it. These forces or reactions must be such that when the frame is loaded its deflections at certain points are as desired. That is, the deflections at points of rigid supports must be zero, etc. The deflections of a frame when acted upon by a number of forces are equal to the sums of the deflections produced by the forces acting independently and this makes a simple analysis of a complex structure possible.

Consider the simple case of the cantilever previously treated and let an unyielding support be placed under the

free end. The beam then becomes a statically indeterminate beam fixed at one end and simply supported at the other. Neglecting the effect of the redundant simple support, let the deflection of the free end point A produced by the load P concentrated at any point, O, be $\Delta_{AO} = P\delta_{AO}$, δ_{AO} being the deflection at A under unit load at O. The reaction at A must be just great enough to produce an equal and opposite deflection of the point A or Δ_{AA} must be equal to Δ_{AO}

or $$\Delta_{AA} = R\delta_{AA} = P\delta_{AO}$$

and $$R = P\frac{\delta_{AO}}{\delta_{AA}}$$

According to Maxwell's theorem of reciprocal displacements the deflection at O produced by a unit load at A is equal to the deflection at A under unit load at O or

$$\delta_{AO} = \delta_{OA}$$

then $$R = P\frac{\delta_{OA}}{\delta_{AA}}$$

The preceding example is of theoretical interest only and is given to explain the method. In order to make the method clearer it will now be applied to the case of a centre-bearing girder swing-bridge which is in the form of a two-span continuous beam. The complete solution, including typical influence lines for shear and moments, is given in Fig. 3.

The girder is statically indeterminate to the first degree and the centre bearing may be considered as a redundant support. Let the centre support be removed and replaced by a unit vertical force. The moment diagram for the resulting simple beam may then be drawn. The girder should be divided into about twenty parts making $\frac{\Delta s}{EI}$ constant. The centres of these parts are then projected down in parallel lines. The ordinates of the moment diagram under these centre points are laid off to scale on the force polygon with a pole at Q and pole length p. The funicular polygon is then drawn with its sides parallel

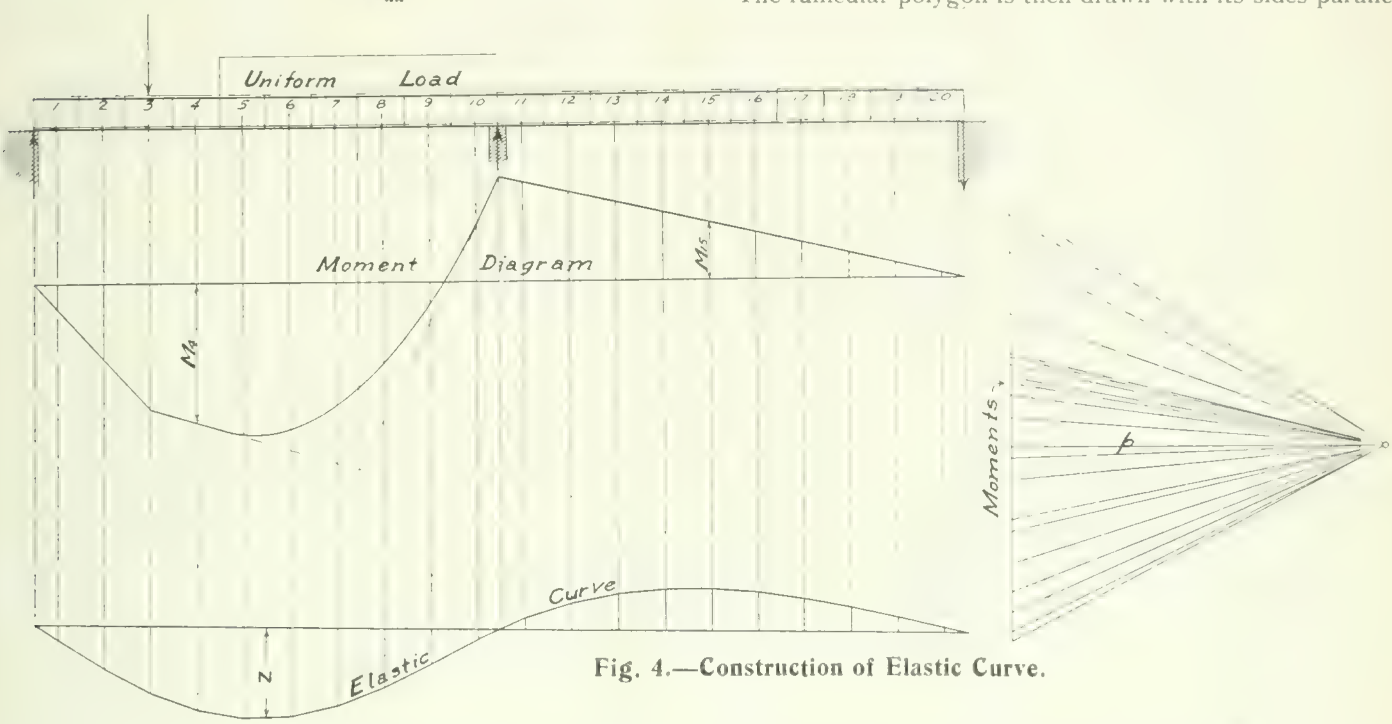


Fig. 4.—Construction of Elastic Curve.

In Fig. 2, the elastic curve of the simple cantilever under a load at A is already found so that when P is unity

$$\delta_{OA} = z_0\, p\,\frac{\Delta s}{EI} \quad\text{and}\quad \delta_{AA} = z_A\, p\,\frac{\Delta s}{EI}$$

or $$R = P\frac{\delta_{OA}}{\delta_{AA}} = P\frac{z_0}{z_A}$$

from which the reaction at A under a load P at any point may be easily found. The elastic curve previously determined then becomes the influence line from the reaction R since R equals the constant $\frac{P}{z_A}$ times the ordinate of the curve under the point of load.

It should be noted that the solution may be made perfectly general and also that the effect of a displacement of the support may be considered. If the support at A settled an amount d, the reaction would then only have to be great enough to produce the deflection $(\delta_{OA} - d)$ at A and the formula for R becomes,

$$R = P\frac{\delta_{OA} - d}{\delta_{AA}} = P\frac{z_0 - \frac{d\,EI}{p\,\Delta s}}{z_A}$$

to the rays and the closing line of the polygon is a check on the accuracy of its construction. As before, the curve tangent to the polygon is the elastic curve and the deflection of the beam under central load is $\frac{z\,p\,\Delta s}{EI}$. Since the centre is so supported that there can be no deflection there, the deflection of the centre point produced by the centre reaction must be equal and opposite to that produced by the superimposed load or for a load P at any point O

$$R\delta_{AA} = P\delta_{AO} = P\delta_{OA}$$

and $$R = P\frac{\delta_{OA}}{\delta_{AA}} = P\frac{z_0}{z_A}$$

The curve tangent to the funicular polygon, the elastic curve, is therefore the influence line of the centre reaction. The different values of z can be readily scaled off and tabulated as desired. When the centre reaction influence line has been constructed, influence lines for moment and shear at any section may readily be constructed and the position of load for maximum stresses determined without the use of involved formulae. When the load is on the right of the section considered, the moment at the section is equal to

$$\frac{Pa}{2}\left(\frac{2x}{l}-\frac{R}{P}\right)$$

in which x is the distance of the load from the right end, a is the distance of the section from the left end and l is the total length of both spans. Also for a load P on the right of the section, the shear at the section is equal to

$$\frac{P}{2}\left(\frac{2x}{l}-\frac{R}{P}\right)$$

From these two equations the influence lines may be drawn as shown in Fig. 3.

The ease with which the deflection at any point of a girder of variable moment of inertia under irregular loading may be obtained is shown in Fig. 4. The girder is divided up as before so that $\frac{\Delta s}{EI}$ is constant. For the assumed combination of loading the centre reaction is obtained from the reaction influence line and the moment diagram is constructed. The average moment ordinates for the different Δ s's are laid off algebraically in order on the load line of the force polygon, positive moments downward and negative moments upward. The funicular polygon is then drawn and the deflection of the beam at any point under the assumed loading is equal to

$$d = \frac{-p\,\Delta s}{EI}$$

The funicular polygon should be drawn continuously from one end to the other and the long closing line when drawn between the end points should pass through the point directly under the centre support as there is no deflection there. This serves as a check on both moments and graphical construction. The effect of a settlement of the centre support on the moments and reactions can, of course, be considered if desired.

Two of the simplest applications of the method have now been explained and the writer hopes that they have been made clear as he believes that the method will be found very valuable. It is not possible for him to give it a thorough treatment here but it is his intention to give an outline of the method in this and following article so that it may easily be applied to the solution of those ordinary statically indeterminate structures used in practice to which it may be applicable. It may also be applied with slight modifications to trussed frames and braced arches as well as to beams and arch ribs, but that can not be taken up here. Its use for the design of the Sciotoville bridge is explained by Mr. D. B. Steinman in the "Engineering Record" of August 28, 1915, page 258. Many very laborious methods of applying the elastic theory are still in use and the writer is at a loss to know why they have not before been simplified.

The theory of virtual displacements is much simpler in most cases than the theory of least work because by its use the effect of the various forces on the structure can be considered separately as acting on a statically determinate frame while the least work theory requires that the effect of all the forces be combined in one equation and the equation differentiated. The latter method seems to be more popular with teachers as it lends itself to nice mathematical treatment but the writer has found that for any but very simple cases the former method, which involves no long equations, is easier to apply and more practical.

The Panama Canal, which has been closed to navigation since September 18, 1915, owing to landslides, will be reopened for vessels of deep draught, April 15, according to an announcement by the acting Governor of the Canal Zone.

METHODS OF CREOSOTING DOUGLAS FIR.

Some important investigations into the effect of commercial treatments upon the strength of Douglas fir bridge stringers have been described in "Wood-Preserving" by O. P. M. Goss, who was in charge of the Seattle Timber-testing Laboratory of the United States Forest Service. The results of these investigations have recently been published by the Forest Service in Bulletin No. 286, and show that bridge stringers treated by the boiling and steaming processes lost from 33 to 35 per cent. of their original strength. Due to this loss in strength, it was necessary to use low fibre stresses in the design of structures built of creosoted timber. In an effort to eliminate this difficulty a large number of experiments have been made with various treatments.

The most successful treatment yet devised for treating bridge stringers and similar forms without loss in strength is that of "boiling under a vacuum." When green timbers are creosoted by this method the treatment requires approximately 26 hours, and is, in general, as follows:—

The timbers are placed in the retort and creosote oil introduced at a temperature of 160° to 180° F. Heat is applied, and the temperature of the oil gradually raised to 190° F. and held at that temperature for 5 to 6 hours, a sufficient length of time to warm the timbers through.

When the timbers are thoroughly warmed, a vacuum of 24 to 27 in. is drawn on the oil, still holding a temperature of 190° F. This vacuum is drawn through an overhead pipe extending from the top of the retort for 36 ft. vertically into the air and returning to the condenser. The purpose of this pipe is to prevent the creosote oil from boiling over into the condenser while boiling under the vacuum. This vacuum is started at 16 to 18 in., and as the timber seasons, is gradually raised to 24 to 27 in. The full period of vacuum is 12 to 16 hours. It is continued until the rate of seasoning of the timber is 0.1 lb. of water per cubic foot of wood per hour. After this finished rate of seasoning is reached the vacuum is broken and pressure on the oil started, which rises as high as 120 to 135 lbs. per square inch, and continues for 4 to 6 hours. The temperature of the oil during the pressure period drops from 190° to 180° F. By this process 10 to 14 lbs. of oil per cubic foot may be pressed into the wood.

This method is a modification of the Boulton process, and at the low temperatures used seasons the wood even better than the old oil-boiling process, which employed so much higher temperatures. Timbers treated by the method of "boiling under a vacuum" are noticeably easier to press than timbers treated under the old boiling process. The edges of the checks which develop, due to seasoning, are very sharp, showing that the wood is not burned at all.

In a note on new antiseptics *Nature* refers to the use of electrolysed sea-water for the disinfection of hospital ships, remarking that though the production of hypochlorite by the electrolysis of salt solution for bleaching purposes, and the powerful antiseptic properties of hypochlorite so produced, have long been known, the idea of electrolysing sea-water on the vessel which is to be disinfected is a novel one. It is due to Dr. H. D. Dakin, whose apparatus consists of an electrolytic cell, which, with a current of 65-75 amperes at 110 volts, yields a solution of two parts per 1,000 of hypochlorite at a cost of about 3d. per 100 gallons. This solution, diluted with an equal volume of sea-water, is sufficiently strong to sterilize floors, decks, latrines, etc. It has been used on the *Aquitania* on her last two voyages, with excellent results.

FEDERAL PLAN COMMISSION'S REPORT

GOVERNMENT RECEIVES RECOMMENDATIONS LOOKING TOWARD THE CREATION OF A TRULY IMPOSING CAPITAL—NEW GROUPS OF GOVERNMENT BUILDINGS, NEW CIVIC BUILDINGS, PLAZAS, BOULEVARDS, PARKS, BRIDGES, TUNNELS, SUBWAYS, ETC., INCLUDED IN PLAN.

SIR THOMAS WHITE, Minister of Finance, last month presented to Parliament the report of the Federal Plan Commission on a general plan for the cities of Ottawa and Hull.

The report is very comprehensive, looking to the future growth and development of the cities of Ottawa and Hull and their environs, and particularly providing for the location and beautification of parks and boulevards, for the location and architectural character of public buildings, and for adequate and convenient arrangements for traffic and transportation.

As the first step in the development, the formation of a federal district for Ottawa and Hull is urged by the Commission. In 1858, when Ottawa was chosen as the capital, Canada was merely a union of the provinces of Quebec and Ontario. Neither province was willing that the other should have the capital within its borders, and accordingly for many years the government was migratory. It was soon seen, however, that the government must have a permanent home, and the matter was referred to Queen Victoria, who chose Ottawa. The choice was a happy one, because, while in the Province of Ontario, Ottawa is only across the river from the Province of Quebec, and is much nearer Montreal, the commercial centre of Quebec, than it is to Toronto, the commercial centre of Ontario.

Now that Canada has become a great federal state, however, it appears to the Commission that there is something anomalous in leaving the capital of the whole federation under the municipal laws of one of its provinces. Federal control alone will ensure the carrying out of really adequate plans. Certainly the needs and dignity of the capital are the business of the people of all Canada.

MUNICIPAL AND RAILWAY CENTRE OF PROPOSED FEDERAL DISTRICT.

Reconstructed Central Portion of Ottawa, Ont., as it will be after Federal Plan Commission's Work is Completed, if Government Proceeds with Programme Suggested. View looking north toward the Parliament Buildings, showing Plaza, proposed Post Office on the right and proposed City Hall on the left.

Moreover, it could not be expected that a municipality would be able to perform such a task on an adequate scale, or that a steady, continuous policy could exist under municipal government.

Improvements Recommended. —The general aspect of Ottawa will certainly be imposing when e proposed improvements are nade. The central area in the city will be a great open space running southward from Chateau Laurier and the Plaza Bridge, and at the same level. Canal, railway and cartage traffic will be on a lower level. The present Grand Trunk station will be enlarged into a Union Station. The present post office will be removed and an imposing one erected facing the Plaza. A new city hall and various law courts, registry offices, etc., will also be constructed facing the Plaza.

A great thoroughfare connecting the east and west portions of the city will be made of Laurier Avenue, which will be widened to 90 feet. The rade of this avenue will be proved by a tunnel at the st end and by the lowering of a bridge across the deau.

GENERAL VIEW OF P

Looking southward from Hull, showing river front and Parliament B

The land west of the parliament buildings will be used departments of the government. Here, in time, a nd group of buildings will be constructed to harmonize those on Parliament Hill. These buildings will house chief governmental activities, but bordering on the st of Major Hill Park and stretching along Sussex et there will be other buildings less ornamental in acter and built for practical utility. The various works of the government will be placed behind these on ast side.

The plan contemplates the devotion of only about 120 acres to government buildings, over and above that actually occupied by the buildings themselves. For this purpose Washington uses about 300 acres; but so much and is not required at Ottawa, owing to the advantageous osition on the high banks of a river.

A drive will be built extending along the banks of Ottawa River from Major Hill Park to the entrance e governor-general's residence. At the entrance to grounds of the government house a spacious circle e created which will give approach also to Rockcliffe

Five new bridges will be built across the Rideau River lso five across the Rideau Canal.

. tunnel will be built under the city, connecting the y entrances from east and west, and all trains will ate through this tunnel. Two general freight areas, at the east and one at the west side, with necessary epots, are recommended.

Industry will be segregated into certain areas, and the height of buildings will be controlled, in order to ensure the government buildings being the dominating groups.

The overflow from the Rideau River will be controlled by the removal from the river channel of the old wooden piers and loose stone, the removal from the river bed of boulders, the dredging of channels through the shoals, the raising of the Minto Bridge, the opening of a channel through the embankment of the Canadian Pacific bridge, and the widening of the channel past Maple Island. These improvements were suggested in the report made upon this subject in 1901 by Andrew Bell, C.E.

It is recommended that the government acquire as a National Park upwards of 100,000 acres to the north of Ottawa.

To provide better connection between the two portions of the business section of Ottawa, a new diagonal street will be constructed which will be carried over the railway and canal by a viaduct.

Somerset Street will be widened and developed as a cross-town artery. Its elevation across the railway tracks at the west end of the city will be lowered, and the bridge will be built across the railway tracks and canal at the east end of the city.

Elgin, Bank, Bronson and numerous other streets and roads will be widened and improved. Street car congestion will be removed wherever necessary. A street car subway under Sparks Street or Wellington Street is recommended, thus removing the cars from Sparks Street, which is narrow and will be greatly congested.

It is recommended that trunk arteries be laid down immediately in proper location, so that outlying areas will be built up to conform properly with them. The present park system is to be improved and other park areas acquired.

OSED FEDERAL CAPITAL.

ǥs, proposed Departmental and Court Buildings and future extensions.

gested. Among the minor recommendations are suggestions too numerous to detail, regarding the widening and extension of streets, building of driveways, bridge approaches, etc.

Survey.—Active field work was commenced in November, 1913, maps being prepared showing all details and desired information in reference to streets, railway and water transportation, etc. The topographical survey was made with sufficient accuracy to enable it to be used for the foundation of an accurate map of 400 feet to the inch. The courses of the principal streets and roads were first run and triangulated within and beyond the city limits, and the courses of the Ottawa and Rideau Rivers and the Canal were determined, and accurate shore lines established.

Elevations with mean sea level at New York as the datum plane were established along the principal thoroughfares, and contours of the cities were laid down as necessary for particular locations.

The railway passenger and freight station at Hull is to be removed to another point. Various streets are to be widened to 86 feet, and a highway constructed paralleling the railway. It is recommended that certain swamp lands be reclaimed and devoted to industries.

Four new bridges are recommended for construction across Brewery Creek and the Gatineau River. It is proposed to park the banks of Brewery Creek, the Gatineau River and the Ottawa River, interfering as little as possible with existing industries.

Three bridges for the Ottawa River are included in the plan; c being at Little Chaudiere Falls; another, of monumental character, to connect Ottawa with the municipal centre of Hull; and a third just below the mouth of the Gatineau River.

The Commission say that the bridge leading from the municipal centre of Hull should be a high-level bridge, and that it would be desirable to provide two levels, one for transportation and one for general traffic, although this bridge is now shown on the plan as having but one level. The present traffic conditions surrounding Victoria Bridge, say the commissioners, suggest this high-level bridge as an improvement for the near, and not the remote, future.

Specific recommendations are made for water terminals and for the development of the water front for commercial purposes wherever possible, care being taken that no real sacrifice will result to existing business interests.

Considerable highway construction is recommended in the report, including Heyworth Road, Old Chelsea Road, Gatineau Road, Renfrew Road, Carleton Place Road, and arteries leading to the Toronto, Kingston, Prescott, Morrisburg and Montreal trunk highways. Various diagonal and branch roads and streets are sug-

Structures belonging to all public utilities were investigated, including sewers, water mains, conduits, pole transmission lines, etc. Tree-planting conditions were examined. Considerable research was made regarding rate of growth of business. Various economic data was gathered regarding the intensity and volume of the different classes of railway business, street railway traffic and facilities, number of government employees, location of government property, etc.

Railway Situation.—The report includes a most comprehensive study of the local railway situation, and recommends that the railways within the district be placed under the control of the governing body of the Federal District. Electrification of the unified system is suggested, with terminal operation and control, the District to acquire by purchase or agreement all trackage and terminals within its territory. Grade separation, requirements for expansion, obstacles placed in the way of growth by present railway situation, present traffic facilities and operation, growth of traffic, future freight handling systems, and numerous other topics also are discussed in the report.

Government Buildings.—The floor area is approximately 3,650,000 square feet, divided as follows: Proposed group west of the western block, 1,500,000 square feet; Sussex Street group, 650,000 square feet; Lyon Street group, on the south side of Wellington Street, 1,500,000 square feet. The area of floor space now owned or rented by the government is 1,750,000 square feet, and there will be required at an early date about 1,000,000 more square feet. Floor areas have been calculated upon the basis of buildings of five stories, areas of basements not included.

District Control.—The practice in the United States and in Europe as regards district control is summarized

in the report, and recommendations are made covering railway areas, dockage areas, height of buildings, residential districts, markets, etc. The building regulations suggested will permit of heights ranging from 80 to 110 feet on the principal streets.

The commissioners have made what they consider a fair estimate, that by 1950 Ottawa will have 250,000 inhabitants, and they have, therefore, planned in general for a city of 350,000 people, with an average density of about 30 people to the acre. This would give a built-up area of about 20 square miles.

Parks and Playgrounds.—In planning parks and playgrounds the Commission has provided for a field of from 8 to 10 acres within a half mile of every residence in the city, and the connecting of all parks by means of parkways, so as to make the park system continuous and comprehensive.

The report recommends the acquisition or extension of 13 parks, 11 parkways and 50 playgrounds and small park areas. Existing parks total 850 acres, but under the new plan Ottawa and Hull will have 3,160 acres of parks and playgrounds.

Other Utilities.—It is recommended that as soon as possible the practice of emptying untreated sewage into waterways be abandoned. It is suggested that some method of disposal be secured to render the effluent harmless. A site at the mouth of Green's Creek, east of Ottawa, is approved of for a disposal plant. It is recommended that Ottawa's incinerating plant be removed to the east of the city in the industrial zone and adjacent to the railway, and that large cars be procured to haul the garbage by railway to the incinerator. Locations for stock yards are suggested which will protect the city from nuisance.

The report states that a policy should be adopted immediately by Ottawa, looking to the ultimate removal of all overhead wiring, both in business and residential districts. It is recommended that street car trolley wires be placed on centre poles between the tracks, the street car transmission wires being placed under the street.

The question of water supply is being given study by the civic authorities, so that the Commission makes no recommendation upon this subject, excepting to suggest that in whatever scheme of improvement of supply is decided upon, all towns and municipalities within the limits of the Federal District should be supplied from a common source adequate for the purpose.

Water transportation receives careful attention in the report, as it involves several serious problems. Recommendations are made that the canal be retained in its

HULL CIVIC CENTRE AND PROPOSED MONUMENTAL BRIDGE.

View looking east over the water-front, showing proposed bridge from Wellington Street, Ottawa, to the Hull Municipal Centre. Victoria Island will be improved without interfering with existing industries.

present location; that the clearance for fixed bridges be established at 12 feet instead of 30 feet, as at present; that the canal be developed to afford recreational facilities; that no more industrial developments be permitted to take place along the banks of the canal between the Rideau River and the Ottawa River; and that as soon as possible such industries as now exist along this stretch of the canal be removed to other locations.

Personnel of Commission.—The members of the Federal Plan Commission are Sir Herbert Holt, chairman; Sir Alexandre Lacoste, K.C., of Montreal; Frank Darling, of Toronto; R. Home Smith, of Toronto; and the mayors of the cities of Ottawa and Hull. This Commission was created by an order-in-council on September 12, 1913, it being provided that the government should pay half of the cost of the plan and that the other half should be paid by the two cities ratably, according to population, the municipal authorities having expressed their desire to co-operate with the government in the work.

The Commission selected E. H. Bennett as consultant on city planning and E. L. Cousins as consulting engineer. Mr. Bennett is a town-planning expert, with headquarters at Chicago, Ill. He was formerly engaged with the firm who were responsible for the excellent lay-out of Washington, D.C., and has done much notable work since entering private practice.

Mr. Cousins has become well known as the chief engineer of the Toronto Harbor Board, and also as consulting engineer to the Rapid Transit Commission of Toronto. Having also had experience as division engineer of the Grand Trunk Railway, and as engineer of bridges, railways and docks for the city of Toronto, Mr. Cousins was able to give valuable assistance to the Commission in solving the questions of street and steam railway traffic, which were very prominent among the difficulties facing the Commission.

Mr. Bennett and Wm. E. Parsons, of Mr. Bennett's staff, were in charge of all architectural and town-planning features. Paul H. Lazenby, engineer of Mr. Bennett's staff, co-operated with Mr. Cousins in all matters pertaining to transportation, statistics and other economic features.

A. E. K. Bunnell was the engineer in charge of the Ottawa office, under whose immediate direction all surveys were carried out and data gathered, with the assistance of H. W. Tate, surveys engineer, and H. S. Bedell, chief draftsman. Mr. Bennett was assisted by H. T. Frost and F. C. Walker in the general plan, and by Mr. Jules Guerin in preparing the perspectives, and by A. Stuart, superintendent of the Ottawa Improvement Commission.

A fireless steam locomotive is used for switching cars and tie trams at an Ohio creosoting plant. The locomotive is of a type which was developed in Europe some years ago and is used around distillation plants, where cinders and live ashes would constitute a fire danger. This locomotive operates by steam, the boiler being charged about seven times every 24 hours at the main boiler, at 150 lbs. pressure. The maintenance cost of this type of switching engine is very low, and its use is said to be very satisfactory in a treating plant yard. Its tractive power is fully equal to that of the usual type, and although it weighs only 22 tons it has pulled as many as 12 loaded gondola cars at a time. Perhaps there are construction contracts on which a locomotive of this type would be an economy.

REINFORCED CONCRETE AS APPLIED TO WATERWORKS CONSTRUCTION.

A PAPER read before the Concrete Institute (England) by Chas. F. Marsh, M.Am.Soc.C.E., on this subject explains how reinforced concrete is particularly adapted to construction of works for the conveyance and storage of water. In this connection, also, the paper by W. W. Horner on "Reinforced Concrete in Sewer Design," which was published in *The Canadian Engineer* for March 30th, will be of interest.

In his introductory remarks Mr. Marsh pointed out that concrete used for structures which had to resist the pressure of water should be richer in cement than that used for the generality of structures. For reservoirs, tanks and dams, where there was sufficient thickness, the concrete should be mixed in the proportions of 1 : 1½ to 3, or 810 lbs. of cement to 13½ cu. ft. of sand and 27 cu. ft. of broken stone or shingle; this mixture was sufficiently watertight for any but very considerable heads, but for pipes and structures of small thickness, say, less than 3 ins., a mortar mixed in the proportions of 1 to 1½, or 1,620 lbs. of cement to 27 cu. ft. of sand, should be used. This mixture was, of course, no more resistant to water pressure than a 1 : 1½ to 3 concrete, but in a thin structure there was a danger in the use of stone or shingle, since two pieces might possibly come together, and any failure in the proper consolidation of the concrete might leave a plane of leakage through the concrete. The size of the broken stone or shingle should not exceed such as would pass through a ¾-in. square-meshed sieve, and might with advantage be ½-in. gauge. It was not advisable to use a richer mixture, as rich mixtures shrunk more when drying and expanded more when wet than leaner mixtures, and consequently cracks were more likely to be induced; while it had been proved conclusively that with proper care in mixing and placing a mixture in the proportions of 1 to 1½ to 3 was practically impervious under considerable heads.

For pipes under pressures exceeding about 40 ft. special linings should be used, such as the sheet steel tubing in a Bonna pipe, or other suitable layer of impervious material.

For any structure which had to resist the percolation of liquids it was advisable, in his opinion, to mix some waterproofing compound with the concrete, or otherwise to provide against leakage by the use of a soap and alum wash, paraffin wax, or other suitable protective coating.

For increasing the imperviousness of concrete or mortar, ordinary hydrated lime had been used very successfully, and could be used in proportions up to 10 per cent. of the weight of cement without injuriously affecting the strength of the mixture.

The concrete should always be kept damp for some time after moulding, depending on the richness of the mixture. The period in the case of a 1 : 1½ : 3 mixture should be about four weeks.

In structures of considerable length, which might be alternately wet and dry, and were exposed to the variations of temperature, it was advisable to provide against cracking, which was almost certain to occur. Such structure should have specially constructed contraction joints, not more than 30 ft. apart, leakage being prevented at the joints by the insertion of sheet lead or copper baffles extending well into the concrete on each side of the joint, and bent over at the extremities to form a good key.

In the construction of all structures to resist the pressure of liquids, special care was necessary to provide

adequate reinforcement against shrinkage due to the setting of the concrete, fall of temperature, and excessive dryness.

Dams.—When reinforced concrete was employed for the construction of dams, the latter were usually of a hollow form of construction, having up-stream and down-stream slabs supported on cross walls carried upon a foundation slab.

From the foundation slab a core wall must be carried down under the bottom of the up-stream slab, and extended well into a watertight stratum. The provision of an adequate cut-off wall was most essential, as some of the dams already constructed of this material had failed owing to the neglect of this precaution.

The up-stream slab was generally constructed with a flat slope not steeper than 1 to 1, since the flatter the slope the more uniform was the pressure on the base.

With a dam of this type, as the reservoir filled, the line of resultant pressure on the base would at first become farther up stream from the centre of pressure on the base with the reservoir empty. When the reservoir had filled for a certain proportion of its depth depending on the slope of the up-stream slab, the line of resultant pressure on the base moved back towards the centre until under the limiting flood conditions it would generally be found to be slightly on the down-stream side of the centre of pressure on the base with the reservoir empty.

The resultant pressure would in no case move very far from the centre of the base, and consequently the intensity of pressure would never vary greatly between the up-stream and down-stream extremities of the base.

In the case of a solid masonry dam the centre of pressure on the base with the reservoir empty was usually at the up-stream extremity of the middle third of the width, and with reservoir under maximum flood was usually at the down-stream limit of the middle third of the width. The consequence of these limits was that with reservoir empty there will be no pressure at the down-stream toe and a maximum pressure at the up-stream heel, while with reservoir full there would be no pressure at the heel with a maximum pressure at the toe. As the reservoir filled the pressure intensity would vary between these extremes.

Elevated Tanks.—Mr. Marsh remarked that perhaps one of the most economical uses of reinforced concrete was in the construction of elevated tanks, of which there are many examples in existence. A reinforced concrete tank could be constructed at a cost of from 40 per cent. to 50 per cent. that of a tank formed of riveted steel plates, and they would in general be less expensive than tanks of pressed steel or cast-iron plates.

When designing circular reinforced concrete tanks it was, in his opinion, advisable to limit the working resistance of the steel to 12,000 lbs. per square inch, since, although the tensile resistance of the concrete was neglected, the elongation of the steel bars must induce elongation in the concrete, and a higher stress in the steel would in all probability cause the concrete to crack. It was also, in his opinion, advisable to insert two series of circular rings in the walls of the tank, one near each surface, in place of one series at the centre of the thickness. It must be remembered that whereas the interior of the tank was kept at a fairly constant state of moisture, and temperature, the outside was exposed to the variations in temperature and humidity, and consequently the two surfaces were under very different conditions affecting the expansion and contraction of the concrete.

Reservoirs Entirely or Partly in the Ground.—In many cases it was not economical, in Mr. Marsh's opinion, to use reinforced concrete for the walls or floor of reservoirs, but it was almost universally an economical material for roof construction.

If a considerable portion of the depth was below ground, the form of retaining wall construction, with a bottom slab at the back tied to the front slab by ribs, was not an economical form of construction, as the excavations had to be considerably enlarged to accommodate the bottom slab.

A well designed as a cantilever, supported from the floor of the reservoir, would reduce the excavation, but great care was necessary to provide ample support at the bottom to prevent failure between the base of the wall and the floor when the reservoir was empty.

If the reservoir was covered, and the covering could be constructed before an excessive loading was brought upon the walls, the roof beams and similar beams formed in the floor could be constructed to support beams along the top and bottom of the wall, which in their turn supported the ends of vertical beams between which the walls of the reservoir could be constructed as slabs with horizontal reinforcements.

The covering usually adopted for reservoirs was of the beam and slab type, similar to ordinary floors, and supported by columns, but small circular reservoirs might be covered with a flat dome in a similar manner to that frequently employed for elevated tanks.

Aqueducts and Pipes.—Open aqueducts built almost entirely above ground level and those for carrying water over valleys might, with economy, be constructed of reinforced concrete, but for those constructed mainly below ground level this material would not be so economical, for the same reasons as given in the case of reservoirs.

Pipes under small heads, say, up to about 40 ft., might be constructed of reinforced concrete without any special impervious material being embedded in the thickness.

PEAT POWDER AS LOCOMOTIVE FUEL.

Experiments in the use of peat powder on locomotives of the State railways have demonstrated that as heavy trains can be pulled and as good speed be made where this fuel is employed as where anthracite is used, according to a statement issued by the Swedish telegram bureau, which has been received from the secretary of the American Embassy at Stockholm. The statement declares that the powder can technically, as well as economically, take the place of anthracite as fuel for locomotives.

The railway directors have decided to undertake the development of this class of fuel by two different methods for purposes of comparison. Two experts have been requested to give complete estimates of the cost of preparing a certain bog for the manufacture of peat powder, together with estimates of running expenses, by the respective methods. The bog selected is said to be that at Hasthagen, about 1½ miles from the station at Vislanda, with an area of about 500 acres.

The T. L. Smith Company, of Milwaukee, Wis., have just completed the two largest concrete mixers ever turned out. Each of these mixers, which are of the tilting type, has a capacity of 108 cub. ft. of mixed concrete per batch. They were built for the Harderway Contracting Company, of Washington, D.C., and are to be used for the construction of an immense concrete dam at Salisbury, North Carolina.

METHODS ADOPTED IN THE CONSTRUCTION OF ROGERS PASS TUNNEL.*

By J. G. Sullivan, M.Can.Soc.C.E.

THE Rogers Pass Tunnel is in the Selkirk Mountains of British Columbia. It is double tracked, five miles long, and, as shown on Fig. 1, lowers the summit of the former line by 552 feet. It also shortens the line by 4.3 miles, eliminates some 2,300 or 2,400 degrees of curvature and avoids the expense and danger of maintaining and operating 4.5 miles of snowsheds.

In order that the plan adopted in the construction of this tunnel may be properly understood and appreciated, it is perhaps advisable to go somewhat into the history of the case. During the period from 1910 to 1913, the traffic of the Canadian Pacific Railway Company was increased so rapidly that it was evident that if the rate of increase continued, the road would have to be double tracked. A very prominent consulting engineer, who reported favorably on the proposal to construct the tunnel, made a further suggestion that it might be necessary to double-track the present line over the mountain and gauntlet the heavy bridges in order to handle the traffic during the period of construction. It can be readily understood, therefore, that the length of time required to complete the work became a matter of anxiety to the company. The author was aware that tunnels in Europe had been driven at a rate two or three times as fast as any long tunnel had been driven on this continent, and he had, in a superficial way, an idea of the methods employed.

The company sent out letters to the contractors who were bidding on the work, in which they were given to understand that the company who could guarantee to drive the tunnel in the shortest time would be awarded the contract. The contractors were also consulted as to penalty and bonus clauses. The company stated that they were of the opinion that $750 per day would be a fair sum.

Methods were studied in order to find out which would be most expeditious in carrying out the work. A combination of ideas resulted in a recommendation for a small working pioneer tunnel, 8 ft. by 8 ft., underneath the main tunnel.

A pioneer tunnel was driven entirely outside the regular section of the tunnel, and a centre heading was driven along the centre of the main tunnel. The functions of the pioneer tunnel were to provide a means of transporting the material from the heading to a point back of where the enlargement of the tunnel was being made, and to provide for the carrying of high-pressure air pipes, water pipes, ventilating suction pipes, etc. In other words, to provide a means whereby the "shooting" at any one point in the tunnel would not interfere with operations at other points. The idea of carrying the drills on a horizontal shaft held in place by heavy jacks was to enable these shafts and drills to be carried on narrow-gauge tracks so that they could be moved backward and forward as required. It was supposed that heavy drills, such as have been used in the past, would be necessary, but it was found that the Leyner drills actually used were so light that they could be handled by one man. The result has been that all drilling in the enlargement has been done from vertical shafts as shown in Fig. 3.

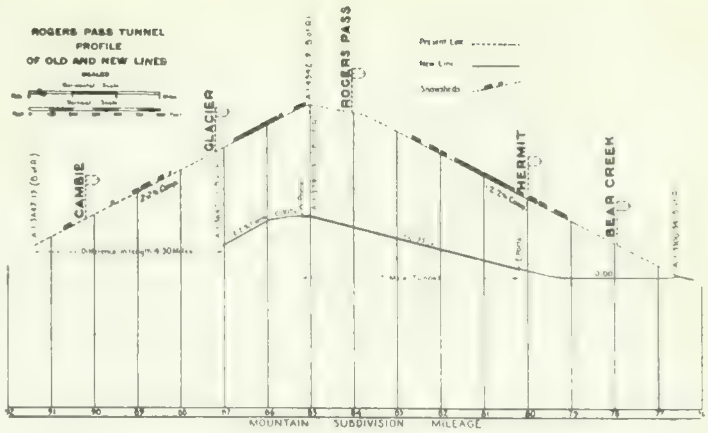


Fig. 1.

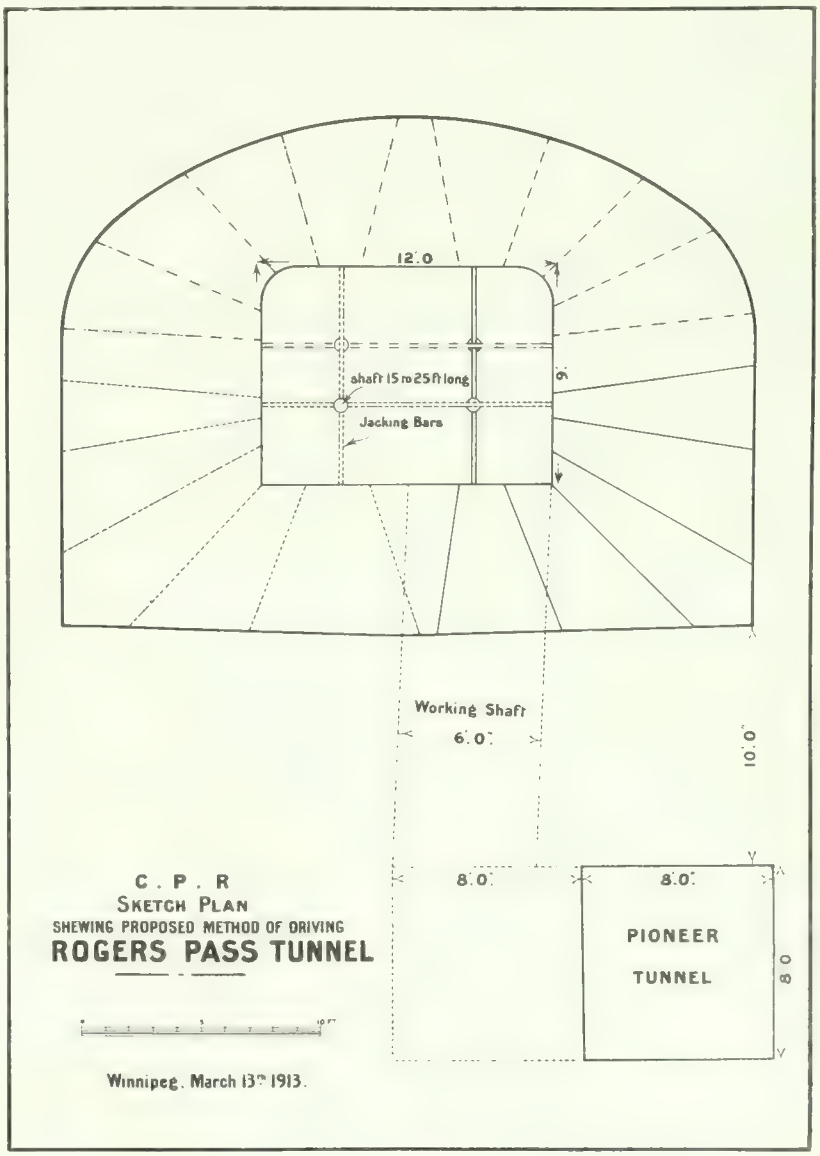


Fig. 2.

*Abstract from a paper read before a Sectional Meeting of the Canadian Society of Civil Engineers, January 13th, 1916.

The pioneer tunnel at the east end was located 50 feet to the north of the centre line of the main tunnel and the pioneer tunnel at the west end 50 feet to the south of the centre line of the main tunnel. The mode of operation was as follows: drilling in the small headings was done in the usual manner, using in general Leyner drills, making an advance of 6 or 7 feet for each round of holes. The muck was shovelled by hand from steel plates into "half-yard" cars and hauled back, either by a mule or small compressed air locomotive. The latter was used entirely when the haul had reached a considerable distance. The muck from the headings was carried out through the cross-cuts into the pioneer tunnel, where

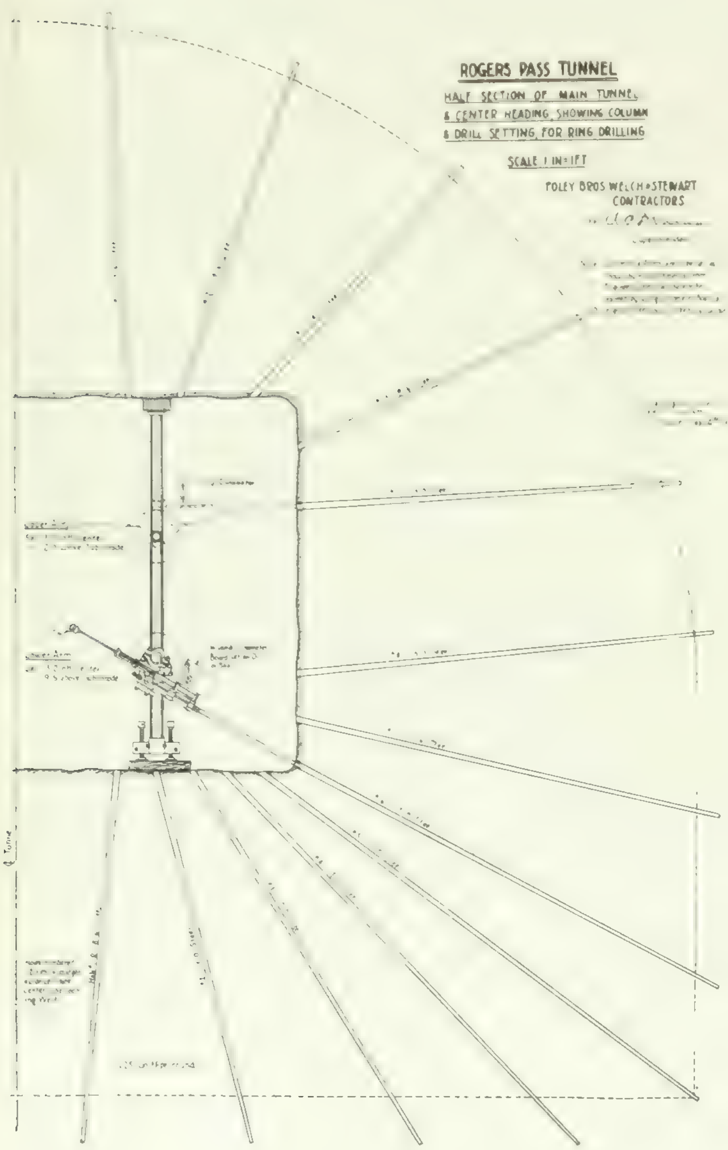


Fig. 3.

it was carried back to another cross-cut, and thence out on a trestle over the standard-gauge tracks through the main tunnel, and dumped into standard-gauge cars. The material was then removed to the fills, as was also the muck, loaded by steam shovels in the enlargement. The muck from the heading on the west end was in a similar manner conveyed into the pioneer tunnel at a cross-cut and back to the main tunnel in another cross-cut, where it was dumped into standard-gauge cars. In the enlargement of the main tunnel the drilling was done well ahead of the shooting. Fig. 3 shows the manner in which the drilling was carried out. The radial holes were at first drilled at right angles to the axis of the tunnel, but the results were not satisfactory, and a change was made. The muck was all loaded by steam shovels into standard-gauge 12-yard capacity dump cars. The shovels had dippers of one and one-half cubic yards capacity and were worked by compressed air. The cars were hauled to the mouth of the tunnel by standard-gauge compressed air locomotives and taken from there to the dumps by standard steam locomotives.

The contract for this work was let on July 1st, 1913. The limit of time for completion was three and a half years, which would end on January 1st, 1917. There was an allowance in extension of time of one day for every ten feet of soft ground encountered, which would require immediate timbering. As there was some 1,660 feet of such ground, the time limit of the contract was extended into June, 1917.

The work completed up to December 19th, 1915, was as follows: 19,610 feet of pioneer tunnel; 24,612 feet of centre heading; 1,660 feet of earth tunnel, and 14,342 feet of tunnel enlargement in rock. At the same date there remained to be driven: 288 feet of centre heading; 10,398 feet of tunnel enlargement.

The best progress made in driving the pioneer tunnel heading was in the month of January, 1915, when 932 feet in the west heading were completed. The best record for a week in the enlargement was 267 feet, and for a month 827 feet. The latter distance was accomplished during the month of August, 1915, in the west end.

From April 1st, 1915, to December 19th, 1915, 12,346 feet of tunnel enlargement was made. This was during the time that the shovels were both working in rock and at a normal rate of speed. Such a rate would require only a little over seven months in which to complete the tunnel. There will, however, be some slowing up in the enlargement between the cross-cuts, which are at the ends of the pioneer tunnels, for the reason that, at present, fans are installed at mouths of pioneer tunnels. Doors were placed in the cross-cuts between the pioneer and the centre heading, and those which were at the back of the shovel were kept closed. When shooting occurred in the enlargement, the door at the first cross-cut beyond the point of shooting was opened and a strong draught was thus created over the pile of freshly-shot muck, making it possible for the men to return to work in ten or fifteen minutes after a shot had been fired. The methods employed in shooting in the enlargement were as follows: One round of holes was shot at a time, the holes in the bottom of the tunnel being shot in advance of the holes on the sides or on top. In some cases the top holes were not shot until all the bottom holes were finished. Usually six or seven rounds of holes were shot before the steam shovel began to take up the muck, thus making an advance of from 30 to 35 feet. The shooting was usually continued until the tunnel became so full of muck that no more shooting could be done. The largest amount shot at one time was 84 feet in eleven hours, which was the record for 20th November, 1915.

All expectations as to speed in the execution of the work have been more than realized. For rock tunnelling, where the rock is of sufficient hardness to stand until the mucking has been completed, the method described can be most successfully worked, and a speed of three miles a year can be easily made at a much less cost than tunnels driven at the same speed by the European

method. Furthermore, the practice of radial shooting has given a great deal less overbreak than would have resulted had the holes been drilled parallel to the axis of the tunnel.

The work was laid out and commenced under Mr. F. E. Busteed, M.Can.Soc.C.E., engineer in charge of double tracking, with Mr. J. W. Sheppard as assistant engineer. It has recently been under the supervision of Mr. W. A. James, M.Can.Soc.C.E., engineer of construction western lines, with Mr. H. G. Barber as assistant engineer; Mr. T. Martin, resident engineer at the west end, and Mr. J. R. C. Macredie, M.Can. Soc.C.E., resident engineer at the east end. The contractors are Messrs. Foley Bros., Welch & Stewart. The construction work has been supervised for the contractors by Mr. A. C. Dennis, M.Can.Soc.C.E.

PRESENT STATE OF EUROPEAN TIMBER-TREATING PLANTS.

The effect of the war on the European timber-treating plants in general has not been very great, according to Dr. F Moll, writing in "Wood Preserving," as most of these plants are situated some distance from the battlefields.

As may be easily conceived, all the Belgian plants have been taken over by the Germans. There are about six plants which are owned partly by private and partly by government interests. In times of peace the government plants were managed by private concerns, and this system has been followed by the German authorities. The Belgian plants are fit for good work, and they are in operation to-day.

In Polonia, scarcely any timber-treating plants are to be found, so we may overlook this country.

In France, the only plants of importance are those that are permanently located, such as the Boucherie, which are mostly small and old. One of the largest creosoting plants in northeastern France is that of Amagne, which has been captured by the Germans. The 150,000 ties found in this plant have been used by German troops for repair and other work, and the plant is not now in operation.

Serbia has one small plant at Chichewash, near Nisch. Dr. Moll visited this plant, and it is now being used as a magazine for the German troops. This plant has two cylinders, 6.5 feet in diameter and 33 feet long, and was constructed by a Hungarian concern known as the Nicholson Actien-Gesellschaft. The process employed is the full-cell with creosote and zinc chloride. The ties found in this plant have all been used for railway track and bridge repairs, and the supply of creosote has been utilized partly for fuel by the German troops.

The following is a list of Canadian patents recently issued through the agency of Ridout & Maybee, 59 Yonge Street, Toronto, from whom further particulars may be obtained: Edwin J. Banfield, plug finishing machine; Toronto Type Foundry Co., Limited, folding plates for folding machines; Gibson Groves, fire alarm system; George Henderson, electro-magnetic signalling apparatus; Fred Rawlings, road planer and surfacer; Gutta Percha and Rubber, Limited, process of moulding and vulcanizing tires; Gutta Percha and Rubber, Limited, tire moulding machine; Samuel Glover and John West, gas producer; Charles O. Bastian, electric incandescent bodies for glow lamps; Edward B. Killen, pneumatic shock absorbing devices.

COAST TO COAST

New Glasgow, N.S.—A new telephone company is proposed, to be owned, operated and controlled by the citizens of New Glasgow, Westville, Stellarton and Trenton.

Brantford, Ont.—E. R. Cross, who has been identified with work in the Alberta oil fields, claims that he has found indications of gas and oil within five miles of Princeton, Ont.

St. John, N.B.—The city has signed an agreement with the Street Railway Company whereby they will do the concreting work of the company at the rate of $5,000 per mile per track.

Hamilton, Ont.—The plant of the Hamilton By-Products Coke Ovens, Limited, will cover an area of 40 acres. The big plant will have a capacity of 10,000,000 cubic feet of gas per day.

Sarnia, Ont.—The cofferdam built around the steamer "Western Star," which foundered last fall, has collapsed. The loss will be in the neighborhood of $32,000. Work will be suspended for the present.

Toronto, Ont.—The cableway over the Whirlpool Rapids at Niagara Falls has been completed at a cost of $60,000. The scheme is financed by Spanish capitalists and has been described before in this paper.

Montreal, P.Q.—Arrangements have been made between Ville St. Laurent and the city of Cartierville, whereby the inhabitants of the former will be supplied with filtered water from the aqueduct of the latter.

Fort William, Ont.—The city council has been approached by the Canada Car and Foundry Company, who located here on payment of a big bonus, with the request that permission be given to dismantle the plant and move it to Vladivostok, Russia.

Toronto, Ont.—A syndicate, said to be backed by the Metropolitan Life Insurance Company, has purchased the entire block of land southwest of the corner of College and Yonge Streets. They propose to establish a new shopping and amusement centre.

Sarnia, Ont.—The electric light plant of the village of Alvinston is to be taken over by the Hydro Commission, according to what can be learned in this city. The engineers from Toronto will inspect the plant and at the same time place a valuation on it.

Lethbridge, Alta.—Drilling operations for oil will be commenced by a British syndicate who until recently have been interested in Galician oil fields. Twelve wells will be drilled and if satisfactory results are achieved the syndicate will erect refineries near here.

Victoria, B.C.—The Minister of Railways has presented figures with regard to the completion of the Pacific and Great Eastern Railway. The cost from Second Narrows, Vancouver, to Prince George is in the neighborhood of eleven and a half millions.

Montreal, P.Q.—The Trail (B.C.) smelter, in which the Canadian Pacific Railway has a large interest, has started construction of a plant for the manufacture of sulphuric and hydrofluoric acid, which is expected to be ready for operation in two months.

Winnipeg, Man.—A circular has been received at the local offices announcing the opening for operation of the

Canadian Northern Railway branch line from Camrose to Alliance, Alta., a distance of 50 miles. This line runs in a southeasterly direction from Camrose.

Toronto, Ont.—The board of control will spend $31,000 on the Humber Boulevard scheme this year. They agreed to spend $25,000 annually for five years and spent only $6,000 last year. The arrangement to reduce the amount has been made with R. Home Smith.

Winnipeg, Man.—At a meeting of the Greater Winnipeg District Water Board the opinion prevailed that the cost of the big work would be less than the estimated sum of $13,500,000. The railway and equipment, which cost $1,535,980, is now a going concern and is at least paying expenses.

Windsor, Ont.—The Chalmers Motor Company, of Detroit, which recently obtained a Canadian charter, with a capitalization of $1,000,000, is to establish its Canadian branch plant at Ford City. A deal has been closed for the purchase of the plant of the Tate Electric Company for that purpose.

Winnipeg, Man.—With two months yet to run, the hydro-electric system of the city of Winnipeg has a surplus of $65,574 to its credit on its year's working. The total revenue for the month of February was $97,327.77 and the operating expenses $71,728.51, leaving a profit for the month of nearly $20,000.

Ottawa, Ont.—According to Sir Rodolphe Forget, the government is going to take over the Quebec & Saguenay Railway. Part of the company's terminals in Quebec have been already taken over and the Quebec & Saguenay will be used as an extension of the Transcontinental to make Murray Bay a winter port.

Vancouver, B.C.—General Manager M. H. McLeod, of the Canadian Northern Railway, announced that on June 1st a daily service would be operated over the company's line in British Columbia. During March more than 1,000 cars of lumber were moved east over the line to prairie cities and this traffic is now growing rapidly.

Sarnia, Ont.—The Mueller Manufacturing Company has just completed and put in operation a melting plant to remelt brass chips. The chips or trimmings are placed in a large melting-pot and fired with coke. As brass has increased in cost about 180 per cent. since the war commenced, this melting of chips will mean a big saving.

Lethbridge, Alta.—A memorial has been sent to Premier Sifton asking that steps be taken to ensure that Macleod and other towns along the Old Man River west of Lethbridge will instal sewage purification plants in order that there may be no recurrence of typhoid outbreak in Lethbridge such as the citizens are now suffering.

Port Moody, B.C.—A number of men with equipment have arrived to start work on the water system installation. They are the employees of the Canadian Pipe Company, Vancouver, who have a sub-contract under the contractors, the Robertson, Godson Company. The contract is for $40,000 and the water will be brought to the city from Scott and Noon creeks.

Victoria, B.C.—Progress on the breakwater has been very satisfactory. There has been placed to date a total of 108,900 tons of granite blocks, while 23,900 cubic yards of concrete, forming the superstructure, has been poured. During the month of March 22,300 tons of rubble was dumped; 7,700 tons of granite blocks were set in place, and 1,700 cubic yards of concrete poured, making five blocks.

Hamilton, Ont.—An increase of over two million gallons of water a day is shown in the report of Engineer Bain of the Beach waterworks, for March. This is attributed to the plants working night and day on munitions. Last March the water used amounted to 278,426,455, whereas this March the total was 343,795,000, an increase for the month of 65,368,545, or a daily increase of 2,108,663.

Winnipeg, Man.—F. K. Herchmer, district inspector of forest reserves, has returned to the city from a trip lasting three weeks in the locality tributary to Port Nelson and The Pas. In commenting upon the progress being made on the Hudson Bay Railway, he stated that the final piece of steel was placed in position on the Manitou bridge, over the Nelson River, thus making possible train service beyond that point.

New Westminster, B.C.—The Canadian Northern Railway Company is preparing to build two car ferries at Port Mann for use in transporting cars between their temporary mainland terminus and Vancouver Island. The material has been ordered, and construction work will be commenced immediately. At the same time a slip will be constructed at Port Mann for loading cars on these barges. Other activities at Port Mann include the construction of two new turntables, the installation of machinery in a machine shop, and the erection of a 1,000-ton ice house. Ice will be brought from Yellowhead Lake to fill this ice house, and the ice used in refrigerator cars.

Vancouver, B.C.—A new traffic arrangement has just been completed by the B.C. Electric Railway Company which will mean that another transcontinental system, the Chicago, Milwaukee & St. Paul line, will be available for lumber manufacturers and other shippers in the neighborhood of Vancouver and New Westminster. Through its connection with the Bellingham Bay & Northern Railway, the Milwaukee line now reaches the international boundary at Sumas. Some time ago a track was built circling that town and connecting the C.M. & St.P. with the B.C. Electric. The connection has been of no value, as permission to handle cars over the Westminster Bridge was not received until just recently.

NEW INCORPORATIONS.

Edmonton, Alta.—The Alliance Power Company, Limited, $250,000.

Govan, Sask.—The Govan Motor and Machine Company, Limited, $20,000.

Corinne, Sask.—The Farmers' Oil and Supply Company, Limited, $6,000.

Calgary, Alta.—Canadian Western Zinc Smelting Company, Limited, $1,000,000.

Cranbrook, B.C.—The Wild Horse Creek Placer Gold Mining Company, Limited, $100,000.

Cobalt, Ont.—National Mines, Limited, $2,000,000. J. A. Rowland, D. H. Stewart, N. D. Tytler.

Toronto, Ont.—Universal Oil Company, Limited, $40,000. L. Sinclair, W. J. Hohlstein, C. Plumb.

Qubec, Que.—Laurentide Sand and Gravel Company, Limited, $49,000. S. N. Parent, A. Lepire, P. A. Galarneau.

Toronto, Ont.—The Crowley Manufacturing Company, Limited, $100,000. T. W. Pinnell, A. W. Gilmour, F. P. O'Hearn; Bournonville Rotary Valve Motor Company, Limited, $500,000. W. Gilchrist, J. Stewart, H. J. Stuart.

The Jeffrey Manufacturing Company has recently organized a contractors' plant department to handle the sale of a line of small rock and ore crushers. Mr. Leroy A. Kling, formerly sales manager of the road machinery and limestone crusher department of the Wheeling Mold and Foundry Company, Wheeling, W. Va., will be in charge of this new department.

Editorial

INTERCHANGE OF IDEAS AMONG ENGINEERS.

The engineering profession, like many other professions, has among its members those who, either from indifference or lack of interest in research work on their own account, unconsciously, perhaps, but none the less surely, continually follow the other man's lead. In most instances he is the man who, always willing to profit from the other man's endeavor, is little disposed to make any contributions by oral or written discussion on subjects of common interest to the engineering profession. Like the proverbial sponge, he takes in all he can; but he is not big enough to give anything in return.

Such an engineer has never thought very deeply as to how the literature of his chosen profession originates. Perhaps there is no man able more adequately to understand this disposition on the part of certain members of the profession, than the editor of a technical paper, one of whose functions it is to draw out engineering discussion along certain specific lines. There are many members of the profession who are reluctant to pass along information of any kind. Every engineer has, or should have, something in the way of information that is of interest to other engineers. No one knows it all, although many of us know a little.

If engineering literature is to fulfil its highest function, then there must be disposition on the part of those who have experience, to impart a little of their own private fund of information for the benefit of others. There should be no exception to the "give-and-take" policy as applied to the engineering profession. The technically trained man who fails to see it in that light will not get the most out of life.

In this connection we would refer to the article by W. W. Pearse on "Stresses in Lattice Bars of Channel Columns," which appeared some weeks ago in these columns, and to a more recent series of articles by E. H. Darling, M.E., on "Impact Formulas for Highway Bridge Design." Both of these articles were the result of much study by their respective authors, and were real contributions to engineering literature, with the expressed wish that they should be of use to the particular branch of engineering to which they referred. Criticism was invited. It came freely, and evidence goes to show that the precipitation of the subjects by Messrs. Pearse and Darling led to a discussion that was worth while, and of value to not only the participants but to a great many others.

One man may spend a great deal of time on a specific problem and believe he has reached a satisfactory solution. Another engineer comes along and will be able, as a result of wider observation or broader experience, to see a phase of the question which probably had not been taken into account by the original investigator. This is all helpful and desirable.

There must be a great deal of valuable information stored away by engineers; information that is being made of no value whatever, either to its owner or anybody else. In many cases there is no very good reason why it could not be let loose without the owner being in any sense of the word a loser.

Engineering societies have rendered very useful service indeed in this direction, and it is to be hoped that during the next few years, when new problems are bound to arise, growing out of the war, there will be a gradually increasing tendency on the part of engineers to be more willing to interchange ideas, and thus contribute, in a real way, to the betterment of the profession.

SOME STATE SECRETS.

Technical papers are public servants, just as are railroads, power companies and many other enterprises. And, like all other public servants, it pays to take the public into their confidence as largely as possible. We therefore feel that our readers should have some idea of how the war has increased the difficulty of publishing a really good technical paper in Canada, so that they can better appreciate whatever slight success we may have had along those lines.

Sheet copper, from which all halftone engravings are made for illustrating the paper, has jumped from 22 cents to 68 cents a pound. Zinc, from which all line cuts are made, is now 48 cents a pound; formerly, 11 cents. Potassium bromide was 45 cents a pound before the war; it is now $7.85 a pound. Yet it is an essential in producing an illustrated paper. Iodine, dragon's blood, hydrochinone, and all other necessary chemicals, have also very greatly increased in cost.

Our white paper costs 57 per cent. more than it did before the war; our red cover paper costs slightly less than five times the former price, is purchasable only in small quantities, and may soon be impossible to secure at any price on account of the dye situation.

However, we're glad we're alive. But when you get your bill for $3 for a year's subscription, just bear these facts in mind, for you are getting a bigger $3 worth than ever before, considering cost of publication.

WATER DISINFECTION.

Standards of water purification have risen considerably the past few years. Physicians recognize that water cannot be too pure. Public health demands more than a palatable potion. It requires a water really free from pathogenic organisms.

H_2O, absolutely pure water, is seldom found in nature. Nearly all surface supplies are polluted to a greater or less extent. The filtration of nearly all drinking water is today a necessity. That is universally acknowledged by most engineers and public health officers.

But even filtration does not yield entirely sterilized water. Modern filter plants operate at a very high efficiency, removing even so much as 99 per cent. of the germs that are in the raw water. Yet, how to get after that stray 1 per cent. is the problem that has bothered the waterworks men.

There are four known ways of accomplishing this, *viz.*: Distillation, disinfection by heat, chlorination and sterilization by ultra-violet rays.

To heat or to distil a public water supply is, of course, impossible from a practical standpoint. Most Canadian

cities are chlorinating their supply. This is effective, but frequently unpleasant to the public, unless administered with great skill and through scientifically arranged machinery, as the taste of chlorine is sometimes very noticeable. Also, chemists and physicians differ in their opinion regarding chlorine's effect upon the body.

The one practical method of sterilization without annoyance to consumers is the ultra-violet-ray process. This is comparatively new, having been readily obtainable only during the past couple of years. Moreover, it is costly, compared with chlorination. When the general public becomes fully aware of the fact that ultra-violet rays passed through water will sterilize it as efficiently as does chlorine, it is quite probable that sentiment in favor of the drugless method will prevail over the difference in cost.

The ultra-violet ray method is now in use in several hundred hotels, stores, private houses, bottling plants, etc., and is also gradually becoming popular with municipalities. The largest municipal supply now being so treated is about two million gallons daily, but a plant is at present under construction which will handle five million U.S. gallons daily. Fifteen lamps are required for this amount. To handle a still larger supply is merely a matter of more lamps, more current, more space and more attendants—in short, more money.

PERSONAL.

J. A. CODERRE, federal forestry engineer, recently addressed the Montreal Chambre de Commerce. Mr. Coderre described the forestry laboratory of the Federal Government, which is situated in a building given by McGill University.

Temporary Brig.-Gen. A. C. JOLY DE LOTBINIERE has been gazetted chief engineer, attached to headquarters units, according to a London cable. He graduated at the Royal Military College, Kingston, in 1883.

J. QUAIL, formerly sales engineer of the Manitoba Bridge and Iron Works, has accepted a position with the Canadian Bridge Co., of Walkerville, Ont., as manager of their western office, located in the Garry Building, Winnipeg.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MANITOBA BRANCH.

The regular meeting of the Manitoba Branch of the Canadian Society of Civil Engineers was held on April 6th, when Mr. M. C. Hendry provided a set of lantern slides of the Panama Pacific Exposition. Mr. Victor Guilbault contributed a discussion on the slides illustrating the lecture, while Mr. W. G. Chace explained those that particularly applied to water power developments throughout Canada.

A move to encourage the zinc industry in Canada has been made by the Minister of Finance who in a resolution before the House proposes to pay a revenue of 2 cents per pound on zinc or spelter containing not more than 2 per cent. of impurities which has been produced in Canada from zinc ores mined in Canada. The above bounty to apply when the price of zinc or spelter in London, England, at the time of production is less than a stated sum, when the bounty shall be equal to the difference between this price and the prevailing London price. No bounty will be payable when the producer receives 8 cents or more per pound. The new bounty, if approved by the House, will not come into effect until after the war, and will only last until July 31st, 1917.

TRADE INQUIRIES.

The following inquiries relating to Canadian trade have been received by the Department of Trade and Commerce, Ottawa. The names of the firms making these inquiries, with their addresses, can be obtained only by those especially interested in the respective commodities upon application to: The Inquiries Branch, the Department of Trade and Commerce, Ottawa, or the Secretary of the Canadian Manufacturers' Association, Toronto, or the Secretary of the Board of Trade at London, Toronto, Hamilton, Kingston, Brandon, Halifax, Montreal, St. John, Sherbrooke, Vancouver, Victoria, Winnipeg, Edmonton, Calgary, Saskatoon, Chambre de Commerce de Montreal and Moncton, N.B. Please quote the reference number when requesting addresses:—

284. Presspahn for electrical insulation—A Manchester importing firm wishes to be placed in touch with Canadian manufacturers of presspahn in the following sizes: Sheets about 23⅜ inches by 31½ inches or larger, in thicknesses from 0.2 m/m up to 4.0 m/m. Quotations are requested per ton of assorted thicknesses. Sample may be inspected at the Department of Trade and Commerce. (Refer File A-769.)

313. Sand, white and silver.—A firm in Glasgow which formerly imported silver sand from Belgium, is anxious to know if suitable deposits are found in Canada. If so, would be glad to receive quotations and particulars.

315. Calcium cyanamide.—A large manufacturing firm in Newfoundland asks for names of Canadian manufacturers of calcium cyanamide.

319. Calcium chloride.—A London firm is desirous of getting into communication with Canadian producers of calcium chloride.

320. Asbestos cement sheets.—A London firm of engineers are in the market for 250,000 square yards of asbestos cement sheets, 3-16-inch thick, and invites quotations from Canadian manufacturers.

323. Belting agency.—A firm in Glasgow which formerly represented large German importing houses wishes to obtain the agency of Canadian manufacturers of rubber, leather and canvas belting. Best references.

324. Brass steam fittings.—A Glasgow firm wishes to obtain the representation of a Canadian house for the above. Satisfactory references.

325. Steel billets and wire rods.—A Coatbridge firm asks for Canadian sources of supply.

326. Rolled steel joists; bars of all sections, rivets and bolts.—A Glasgow house will be glad to receive catalogues and quotations c.i.f. Glasgow quay.

327. Steel joists.—A large Glasgow firm would be pleased to receive quotations for say 150 tons steel joists to the following sections, or nearest procurable sizes: 9-inch by 4-inch by 21 pounds, 8-inch by 4-inch by 18 pounds, 7-inch by 4-inch by 16 pounds, 6-inch by 3-inch by 12 pounds, 5-inch by 3-inch by 11 pounds; all in 40-foot lengths.

328. Galvanized fencing wire.—A Glasgow firm desires to know if galvanized fencing wire can be obtained from Canada. Supplies formerly procured from Belgium.

329. Iron or steel bars.—A Glasgow firm is open to purchase iron or steel bars, notably bulb tee bars 1½ by 1⅜ equal 2½ pounds per foot, and varillas ¾-inch by ⅜-inch by $8\frac{\text{oz.}}{\text{ft.}}$

331. Wood screws.—A firm of wholesale hardware merchants at Manchester wishes to be placed in touch with Canadian manufacturers of wood screws from ½-inch to 3 inches.

340. Nails.—A New York firm of exporters desires to be placed in touch with Canadian manufacturers of wire nails, wrought nails, and galvanized wrought nails, to be used for boat building purposes.

345. Carbide.—A South African firm at present importing large quantities of Norwegian carbide are desirous of obtaining c.i.f. quotations on the Canadian product.

338. Machinery.—The director of a railway in India who has made arrangements for the building of a new plant wishes to be put in touch with Canadian manufacturers of saw-mill and veneering machinery.

The Road Board of Great Britain recently advised county authorities of its intention to loan $1,000,000 during the fiscal year 1916-17 to aid in improving road surfaces.

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MILWAUKEE ACTIVATED SLUDGE INVESTIGATIONS

A RESUME OF RESULTS OF EXPERIMENTS CARRIED ON DURING THE YEAR 1915 BY THE MILWAUKEE SEWERAGE COMMISSION.

By R. O. WYNNE-ROBERTS, M.Can.Soc.C.E.

THE second annual report of the Milwaukee Sewerage Commission (see *The Canadian Engineer*, October 28, 1915) has just been published. It is a volume of over 200 pages and has many drawings, diagrams, photos and tables which afford the reader abundant matter to ponder over.

The activated sludge process has been investigated in various scales of magnitude ranging from the laboratory to a large working installation, and also by the intermittent and continuous methods of charging. The writer well remembers visiting Exeter and Yeovil (England) in 1897 to study the septic tanks and filters, and has watched the vicissitudes of that system up to the present with interest, because great and excellent results were anticipated by enthusiasts who had not fully considered the problem. The septic tank is capable of doing good work when carefully managed, and the biological filters have proved satisfactory when operated properly. The septic tank was boomed and the predictions were great, but its originators were not entirely to blame for the undue boosting it received. The public was then seeking a solution of the sewage problem as it is doing to-day, although in the meantime much progress has been made.

The activated sludge process is capable, under scientific control, of producing such wonderful results, that the public is apt to enthuse and raise too high expectations to be realized in practice. Hence the fortunate fact that the process is receiving careful and scientific investigations in its early stages before errors are made on any serious scale. On the other hand, the Milwaukee Sewerage Commission is to be congratulated on its enterprise in undertaking such investigations in a comprehensive manner.

Fig. 1.—Panoramic View of Tanks.

A resumé of the experiments tried out during the year was as follows: Fine and coarse screening; grit chambers; sedimentation and sludge digestion in Imhoff tank; colloidal treatment by slate tanks; chemical precipitation using lime and iron; electrolytic treatment by Lautzenheiser process; percolating filters and final sedimentation; sterilization by liquid chlorine; activated sludge process by fill and draw method; activated sludge process by continuous flow method; dehydrating sludge by pressing, gravity and by draining on beds.

In the present review experiments other than those on the activated sludge process will not be discussed. These experiments were started on March 1st, 1915, by

means of two 1½-inch glass tubes 6 ft. long, and next in a tank 32 ft. 0 in. x 10 ft. 6 in. and 9 ft. average depth, on the fill and draw method which was put into operation on March 20th, 1915. The continuous flow tank was put into commission on June 28th, and had the capacity of 22,600 U.S. gallons (18,830 Imperial gallons).

The foregoing experiments produced such promising results that the commission decided to install a plant capable of treating two million (U.S.) gallons per day, with the view to ascertaining the results under normal working conditions. This plant consists of eleven reinforced circular concrete tanks 30 ft. internal diameter by 13 ft. deep, eight of which are used as aerating tanks, one as a final sedimentation tank and two as sludge aerating tanks. The layout is shown in Figs. 1 and 2. The total capacity of the eight aerating tanks is 360,000 U.S. gallons, two sludge tanks 88,200 U.S. gallons,

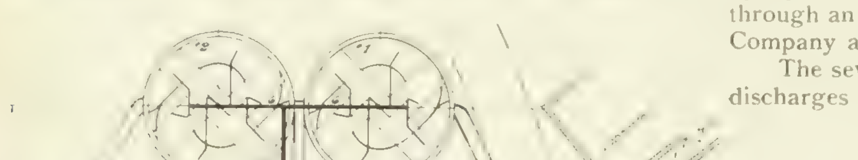

Fig. 2.—Plan of Tanks.

and the sedimentation tank 33,000 U.S. gallons. The daily working capacity of the plant with 25 per cent. activated sludge in the aerating tanks and four-hour tank passage is 1,620,000 U.S. gallons, and by reducing the tank passage period to three hours the working capacity is increased to 2,160,000 U.S. gallons.

Each of the aerating and sludge tanks is divided by a baffle wall which makes a spiral running through chamber about 6 ft. wide and 114 ft. long. Each chamber has a sloping bottom in the apex of which 12-in. x 12-in. filtros plates are set in castings built in units containing from five to seven plates. These castings have an air duct cast in them which discharges the air through a brass orifice to the under side of the plate. This orifice is designed to pass 2 cu. ft. of air per minute under 5 pounds pressure per square inch. This capacity being based upon our experiments showing maximum air required to be .25 cu. ft. per minute per square foot of tank surface.

The baffle walls separating the running through chambers of the eight aerating tanks are 2 ins. thick, built of Hyrib plastered with cement mortar. Those in the two sludge tanks are 6 ins. thick, built of the same material. The extra thickness is here necessary because each of the sludge tanks is divided into two distinct compartments permitting one compartment to be emptied while the other is being filled and aerated.

The sedimentation tank is built with a hopper bottom terminating in a 4-ft. diameter cast iron pipe 24 ft. below bottom of tank, from near the bottom of which a 12-in. pipe extends to the top of the tank. Inside of this 12-in. pipe is a 1-in. pipe for delivering air to the sludge by which it is lifted from the bottom of the 4-ft. pipe and delivered to the sludge tanks, or to the sludge presses.

The compressed air for the two-million-gallon plant is furnished by means of a Connorsville blower having a capacity of 2,400 cu. ft. of free air per minute to five pounds per square inch pressure. This is operated by a 75 h.p., a.c., variable speed motor. The air, after passing through an Excelsior filter, is measured by General Electric Company air meters.

The sewage is taken from an intercepting sewer which discharges about 12,000,000 gallons of sewage per day and some of this originates seven miles above the outlet and is quite septic on reaching the works.

As this plant was not completed until the end of 1915, not much information is available as to the results obtained.

Without in any way minimizing the excellent work done at Milwaukee, and before discussing some of the results obtained there it will be instructive to refer to a few of the engineering considerations, which require to be further and more fully developed. These are referred to in the report and go to prove that to obtain the maximum efficiency at the least cost it involves many studies and experiments.

"Activated sludge accomplishes four principal functions: The clarification of the liquor, removal of the putrescible organic matter, reduction of bacteria, and finally, if the process be continued a sufficient period, oxidizes the ammoniacal compounds into nitrates."

William R. Copeland, the chief chemist, defines the process as follows:—

"The sludge embodied in sewage, and consisting of suspended organic solids, including those of a colloidal nature, when agitated with air for a sufficient period, assumes a flocculent appearance very similar to small pieces of sponge. Aerobic and focultative aerobic bacteria gather in these flocculi in immense numbers, from 12 to 14 million per c.c.; some having been strained from the sewage, and others developed by natural growth. Among the latter are species which possess the power to decompose organic matter, especially of an albuminoid or nitrogenous nature, setting the nitrogen free; and others, absorbing this nitrogen, convert it into nitrites and nitrates. These biological processes require time, air and favorable environments, such as suitable temperature, food supply and sufficient agitation to distribute them throughout all parts of the sewage."

As the supply of air under suitable conditions is a primordial requirement, experiments were made with air jets, filtros plates, monel metal cloth, and Kisselghur, to ascertain the best practicable method of diffusing the air and the relative area of the diffusers to that of the tank was investigated. Whether superactivated sludge will lead to an economy in the supply of air in the tanks is a

most interesting problem to study. The most effective depth of sewage under aeration to absorb the maximum of oxygen as the air passes through, as well as the effects of low temperature of the air on the efficiency of the process, are receiving attention, whilst the best method of applying the process according to the varying hourly flows of sewage and to the fluctuating strengths of the liquor will afford engineers and chemists ample scope for their ability and ingenuity. The advantages of continuous flow over intermittent flow methods do not appear to be very pronounced except as to the cost of construction and operation, where the continuous flow tanks are superior, although "with a wide variation in strength of sewage and rate of flow a more uniform standard of effluent can be obtained with the fill and draw method because it is susceptible of better control."

The question of how best to reduce the sludge to a fertilizer and extracting the grease is a most important one, because it is anticipated that sludge, which is now often an abomination to be got rid of by any means, will in future be saleable at profit, and if this is accomplished, then the ancient slogan of "back to the land" will be realized with advantage to the municipal authorities and to the farmers.

If space is available, fuller references will later on be made to the various engineering problems referred to, because the success of a sewage treatment plant depends largely on the careful development of details. A fifty-million-gallon plant is not constructed very often and, furthermore, what might answer admirably under scientific management which can be obtained for large works, may not be equally attainable at average installations.

Mr. Copeland's report is a comprehensive one and provides statistics which show what results were obtained, and these will now be discussed.

The sewage was screened through a ¾-in. bar screen to remove the coarse materials, passed through a grit chamber to settle out mineral substances and sampled every hour in a gallon measure. A representative portion of the sample—about 250 c.c.—was taken out each hour, chloroformed and put into a bottle which was packed in ice so as to suspend biological changes pending the time when a 24-hour collection of samples was available for analysis. Settleable solids were measured in tapering glass vessels; portions of sewage were filtered through filter paper, and these, as well as unfiltered sewage, were evaporated to dryness to determine the weights of the total and soluble solids—the difference being recorded as suspended matter. Free ammonia was determined by direct Nesslerization. The tests for numbers of bacteria contained by the sewage were made upon agar incubated at 20° C. for 48 hours, the sample being diluted with sterile distilled water.

From the results obtained at Manchester by the originator of the activated sludge process, Messrs. Adern and Lockett, it would appear that the time required for the maturing of sludge was in the first instance about six months, but this period has been reduced considerably. As already stated, the first experiments upon this process at Milwaukee were started in the laboratory about March 1st, 1915. The apparatus used consisted of two glass tubes 6 ft. long by 1¼ ins. diameter. At the bottom of one tube a filtros plate was placed to diffuse the air through the mixture. A small glass tube was placed inside the other tube to carry the air to and discharge it near the bottom of the tube in an open jet.

On March 6th these tubes were filled with raw, coarse screened sewage and some sludge from the final sedimentation tank of the 8-ft. sprinkling filter, air was turned on, of unknown quantity, but sufficient to keep the mixture in violent agitation. On March 10th, or at the end of four days' continuous aeration, the sewage was clarified, the sludge had a brown color and settled readily. The clear liquor was decanted off, raw sewage substituted and the mixture continuously aerated for another 24 hours, when the air was shut off.

Within one-half hour the sludge had settled, leaving a clear supernatant liquor, containing 20 parts per million of nitrates. Fresh sewage was again placed in the tubes; within 12 hours after aeration began nitrites and nitrates were present and at the end of 24 hours' continuous aera-

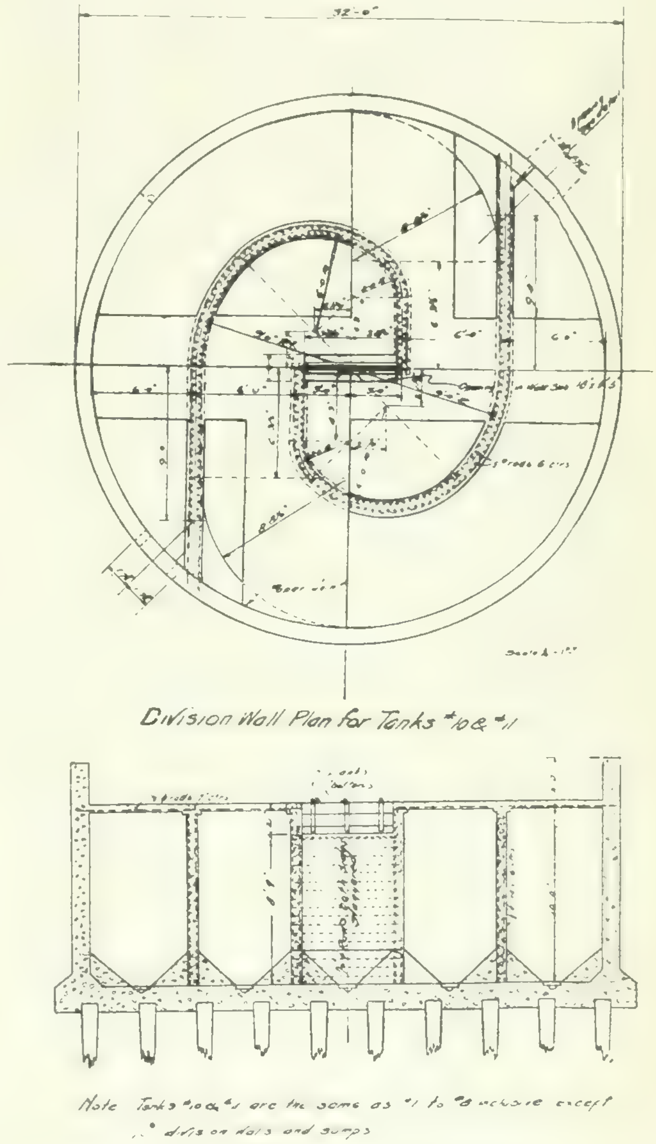

Fig. 3.—Section of Tank.

tion the liquor contained but a trace of free ammonia, one-half part of nitrite and 20 parts of nitrates.

Dr. Edward Bartow, of Urbana, was also able to produce activated sludge in a few days.

The laboratory test showed that an open air jet gave about equal results as the filtros plate diffuser. The results gave such promise that a tank which had been used for chemical precipitation experiments was converted into a fill and draw tank for trying out the activated sludge process. This tank has a capacity of 22,200 (U.S.) gallons,

[illegible] 18,500 Imperial gallons. There are 50 filtros plates, each 1 sq. ft. in area. The area of the tank is 336 sq. ft. and filtros plates 50 sq. ft. or a ratio of 1 to 6.7. The air was measured by a venturi meter and controlled by a hand valve. The cycle of operation was, roughly, as follows:—Filling, 1 hour; aeration, 3½ hours; settling, ½ hour; decanting, 1 hour. Samples were collected before and after treatment and the average monthly results of the analyses were as follows:—

	Crude Sewage	Effluent from Tank	Percentage Removed
Settleable solids in two hours, cu. yds. per million gallons	17.5	0.8	95.4
Suspended matter, in p.p.m.	250	12	95.3
Total solids, in p.p.m.	1,067	777	27.1
Nitrogen as free ammonia, p.p.m.	14.61	9.70	32.4
Nitrogen as alb. ammonia, p.p.m.	8.79	2.84	72.3
Nitrogen as organic nitrogen, p.p.m.	30.3	13.5	55.5
Nitrogen as nitrite, p.p.m.	0.24	0.81	
Nitrogen as nitrate, p.p.m.	0.42	2.51	
Oxygen consumed, p.p.m.	116	23	80.0
Alkalinity, p.p.m.	255	240	
Chlorine, p.p.m.	185	183	
Dissolved oxygen, p.p.m.	1.1	5.2	
Temperature, degrees Fahr.	62°	63	
No. bacteria per c.c. at 20° C. in millions	2.100	0.115	95.3

This tank treated sewage at the following average daily rates:—

June ...... 52,911 gallons, 1.76 cu. ft. of air per gallon
July ...... 56,308 gallons, 1.91 cu. ft. of air per gallon
August .... 72,539 gallons, 2.05 cu. ft. of air per gallon
September . 76,950 gallons, 2.00 cu. ft. of air per gallon
October ... 57,097 gallons, 1.36 cu. ft. of air per gallon
November .. 60,824 gallons, 2.14 cu. ft. of air per gallon

Average amount of sewage treated daily, 62,771 gallons.
Average amount of air used per gallon, 1.87 cubic feet.

The figures for May and December are not given.

It is interesting to note that whereas Messrs. Adern and Lockett, in their experiments in 1914, found the amount of free air used did not exceed 15 cu. ft. per square foot of tank area per hour with a sewage depth of about 5 ft., whereas the average at Milwaukee for sewage 9 ft. deep was about 25 cu. ft., Mr. Adern thought 12 cu. ft. would suffice, and Dr. Bartow is reported to have succeeded in using still less quantity of air.

Turning now to the continuous flow method. Another of the former chemical precipitation tanks was remodelled for this purpose. This tank is 32 ft. 0 in. x 10 ft. 6 ins. x 10 ft. 0 in. deep, divided longitudinally into three compartments. The sewage is admitted into and flows through the left-hand into the right-hand and out by the central compartment, and in doing so it travels 81 ft. and is aerated. The sludge, being very flocculent, is carried forward and settles in the sedimentation chambers whence it is pumped back to the point of sewage inlet. The air is distributed and diffused in the same way as in the fill and draw tank.

The continuous flow tank was operated by filling it with sewage on June 28th, 1915, running in 1,200 gallons of sludge from the Imhoff tank and from the secondary sedimentation tanks of the sprinkling filters. More sludge was run in on July 13th and 16th, and by the 19th July the black sludge had by aeration turned brown. The tank was put into working commission on August 5th. Samples were taken and analyzed and the following figures show what were the average results during four months, August to November inclusive.

	Crude Sewage	Effluent from Tank	Percentage Removed
Settleable solids in two hours, cu. yds. per million gallons	20.77	2.4	87.7
Suspended matter, p.p.m.	310	15	95.2
Total solids, p.p.m.	1,165	834	28.3
Nitrogen as free ammonia, p.p.m.	15.7	7.16	55.0
Nitrogen as alb. ammonia, p.p.m.	9.53	4.77	50.0
Nitrogen as organic nitrogen, p.p.m.	34.6	11.1	67.7
Nitrogen as nitrite, p.p.m.	0.20	0.41	
Nitrogen as nitrate, p.p.m.	0.17	5.94	
Oxygen consumed, p.p.m.	123.0	22.0	82.3
Alkalinity, p.p.m.		192	
Chlorine, p.p.m.		196	
Dissolved oxygen, p.p.m.	1.09	4.3	
Temperature, deg. Fahr.	64	64	
No. of bacteria at 20° C., mil.	1.620	0.086	95.0

The continuous flow tank treated sewage at the following average daily rates:—

August .... 19,745 gallons, 4.52 cu. ft. of air per gallon
September .. 47,755 gallons, 2.01 cu. ft. of air per gallon
October ... 59,137 gallons, 1.62 cu. ft. of air per gallon
November . 60,393 gallons, 2.09 cu. ft. of air per gallon

Average amount of sewage treated daily, 46,760 gallons.
Average quantity of air used per gallon, 2.56 cubic feet.

Omitting August, the averages are: Amount of sewage treated, 55,762 gallons; quantity of air used, 1.91 cu. ft. per gallon.

It is instructive to compare the results obtained by the two methods.

	Fill and Draw Method	Continuous Method
Reduction in settleable solids	95.4%	87.7%
Reduction in suspended matter	95.3%	95.2%
Reduction in total solids	27.1%	28.3%
Reduction in free ammonia	32.4%	55.0%
Reduction in alb. ammonia	72.3%	50.0%
Reduction in organic nitrogen	55.5%	67.7%
Reduction in oxygen consumed	80.0%	82.3%
Reduction in bacteria	•95.3%	95.0%
Average number of tank volumes treated daily	2.8	2.5
Average quantity of air per gallon in cubic feet	1.87	1.91

There would appear to be but little difference in the results obtained by the fill and draw or the continuous flow methods. A number of experiments, however, were made apart from the general tests and the results point to possibilities of great interest.

The cost of furnishing compressed air at five pounds pressure is estimated by Mr. Halton at $2.50 per million cubic feet of free air and on this basis the cost of treating sewage on the fill and draw method, using 1.87 cu. ft. per gallon, would be about $4.67 per million U.S. gallons, and by the continuous method, using 1.91 cu. ft. per gallon, $4.78 per million U.S. gallons, but Mr. Copeland states that 1,000,000 (U.S.) gallons can be clarified, freed from 95 per cent. of its bacteria and rendered stable for five days by the application of 1.75 cu. ft. of air per gallon at a cost of $4.38, which includes overhead charges upon that portion of the plant devoted exclusively to treatment of sewage but excludes plant and engine room labor and cost of disposing of the sludge.

GRAPHICAL TREATMENT OF ELASTIC RIBS.*

II. TWO-HINGED ARCHES.

In the preceding article a graphical method for obtaining the elastic curve of any beam or rib was given and the application of this method to the solution of two-hinged arches will now be shown. The method itself is perfectly general and applies to oblique and unsymmetrical arch ribs, but in order to simplify the case and make it as practical as possible, a common symmetrical arch will be taken as an example. When applied to unsymmetrical arches the procedure is slightly different but not more difficult.

Ths example of a two-hinged arch rib given in Merriman & Jacoby's "Roofs and Bridges," Part IV., will be taken so that the graphical results may be compared with the true values. The rib is a solid web parabolic rib of uniform depth, 258-foot span and 26-foot rise. The moment of inertia of the rib is assumed to vary as the secant of the angle of inclination of its axis with the horizontal. In this case there are 20 panel points and as 20 is a convenient number of divisions of the arch rib, they were made the same; but the number of divisions need not, and usually does not, correspond to the number of panel points. The rib was laid out to scale as in Fig. 1 and divided into 20 parts such that $\frac{\Delta s}{EI}$ is a constant. The centre points of the divisions were then projected in parallel lines to the right and downward.

The horizontal reaction is obtained in the same manner as in the graphical method for spandrel braced arches as explained in "Roofs and Bridges," Part IV., except, of course, the displacements of the arch rib must be obtained in a different way. The theory is the same as that given in the previous article. Consider the horizontal reaction as a redundant element and put the left end of the rib on rollers so that it is free to move horizontally. The rib is then statically determinate. If a vertical load of unit intensity be placed at any point, O, the left end will be displaced horizontally by a certain amount δ_{AO} and the value of H must be just great enough to produce an equal and opposite displacement. Let the horizontal displacement of the left end A under a unit horizontal force at A be δ_{AA}, then

$$H = P\frac{\delta_{AO}}{\delta_{AA}}$$

which gives the true value of H for the vertical load P at any point. The effect of horizontal or oblique loads will be considered later. It follows from Maxwell's Theorem that δ_{AO} the horizontal displacement of A under a unit vertical load at O is equal to δ_{OA} the vertical displacement of O under a unit horizontal load at A, and hence,

$$H = \frac{P\delta_{OA}}{\delta_{AA}}$$

The solution of this equation requires the displacement of the arch rib when acted on by a unit horizontal force alone and these may most easily be obtained graphically by constructing the elastic curve for the rib under that loading. If y is the ordinate of the neutral axis of the arch at any point relative to the line through the hinges the moment at any point is equal to $Hy = y$, since H is unity. The equation of the elastic curve is therefore $\Delta' y = \frac{\Delta s}{EI}\sum_0^c yx$ which gives the y-displacements of any point O

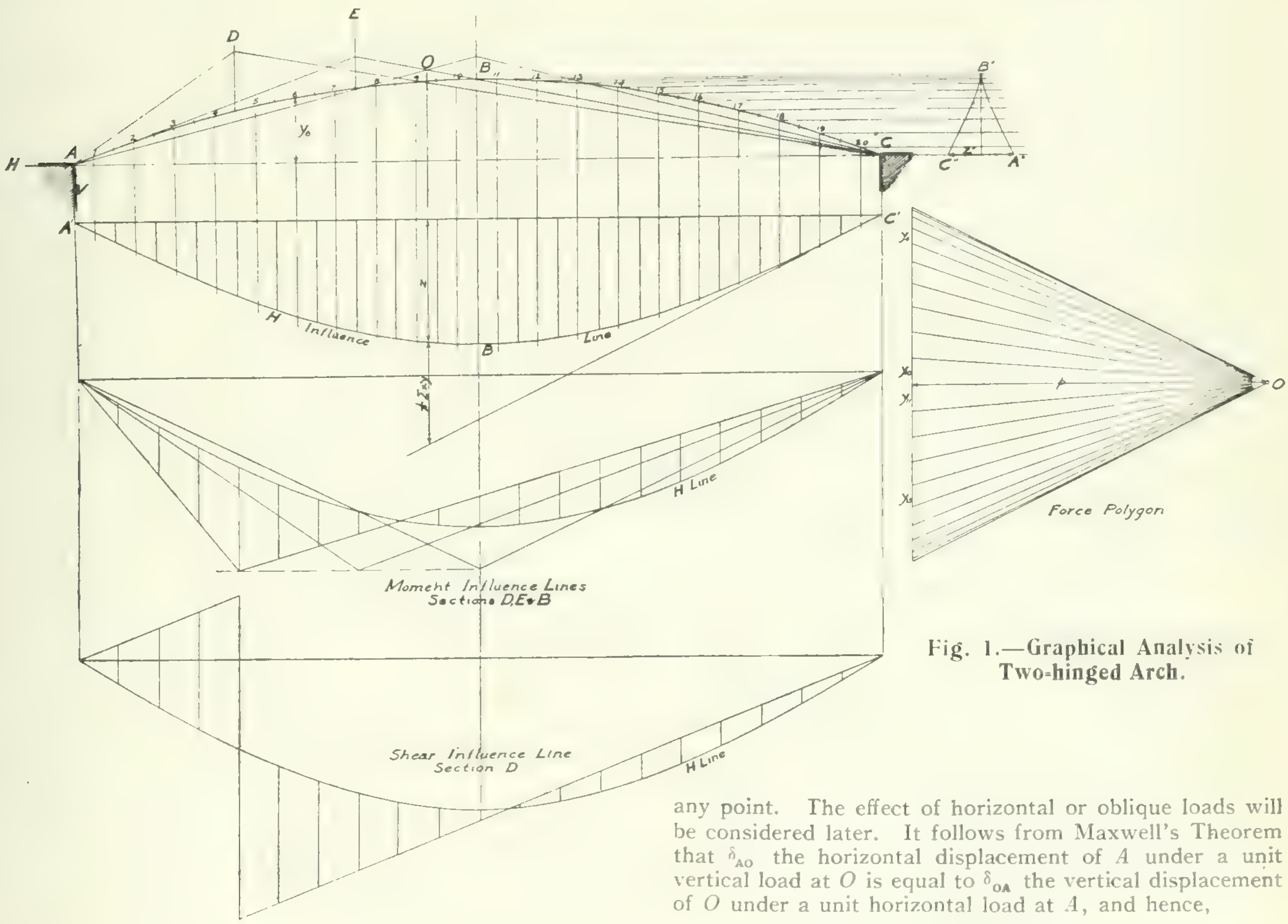

Fig. 1.—Graphical Analysis of Two-hinged Arch.

*Second article by C. S. Whitney, M.C.E., in "The Cornell Civil Engineer."

relative to the tangent at C, the left end. The value of x is measured from the point O.

The elastic line is constructed as before merely by laying off the values of the moments y on the load line, selecting a convenient pole and drawing the funicular polygon $A'B'C'$ with its sides parallel to the rays of the force polygon. The vertical ordinate between the curve tangent to the sides of the funicular polygon and the tangent to it at C' is then equal to $\frac{\Sigma y x}{p}$, which gives the displacement relative to the tangent to the arch rib at C. The displacement relative to the line through the hinges will therefore be given by the ordinate between the curve $A'B'C'$ and the straight line $A'C'$ and

$$\delta_{OA} = \frac{z p \Delta s}{E I}.$$

The value of z is measured to the same scale as the arch rib and the pole distance p is measured to the same scale as the load line.

The value δ_{AA} is obtained by the use of the formula

$$\Delta x = \int_A^C \frac{M y \, ds}{E I} = \frac{\Delta s}{E I} \sum_A^C y^2.$$

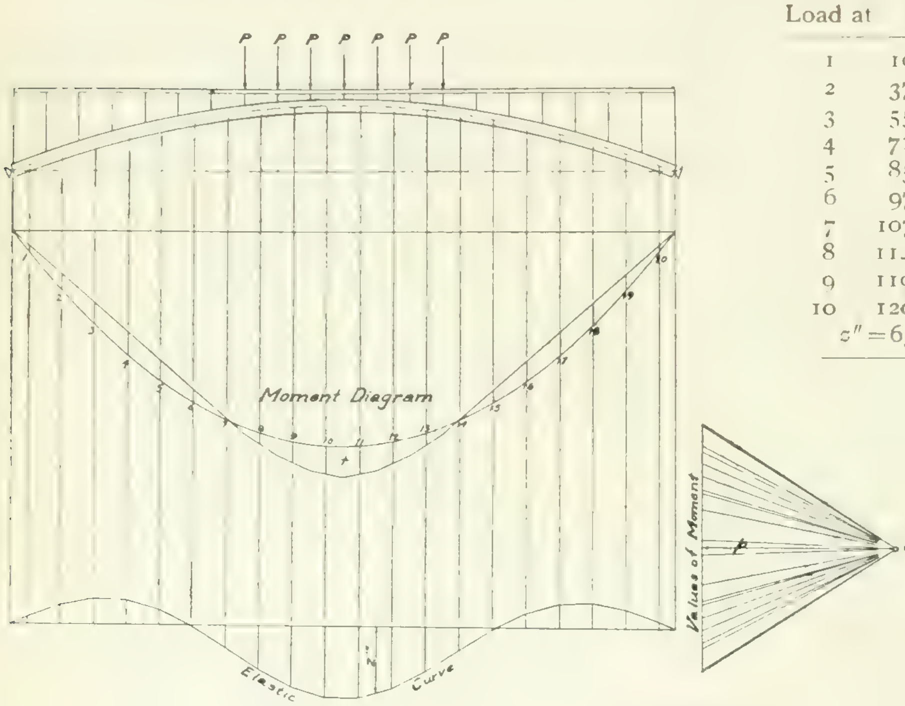

Fig. 2.—Construction of Elastic Curve—Two-hinged Arch.

This summation is performed graphically by means of the funicular polygon $A''B''C''$ which is drawn with its sides perpendicular to the rays of the force polygon previously used. It should not be necessary to go into the properties of funicular polygons here. They are fully explained in Church's "Mechanics" and other texts. The smooth curve tangent to the sides of the funicular polygon is the x-elastic curve and from it the x or horizontal displacement of any point relative to any other point can be obtained by measuring the horizontal distance between the two corresponding points on the elastic curve. The horizontal displacement of A relative to C is equal to

$$\delta_{AA} = \frac{A''C'' p \Delta s}{E I} = \frac{z'' p \Delta s}{E I}.$$

The values of δ_{OA} and δ_{AA} having been obtained, we may write for the value of H the following expression, since the same pole length p was used for both

$$H = P \frac{\delta_{OA}}{\delta_{AA}} = P \frac{\frac{z p \Delta s}{E I}}{\frac{z'' p \Delta s}{E I}} = P \frac{z}{z''}.$$

The y elastic curve $A'B'C'$ is thus seen to be the influence line of the horizontal reaction and the horizontal reaction produced by a load P at any point is equal to the corresponding y elastic curve ordinate multiplied by the constant $\frac{P}{z''}$.

The remarkable simplicity of this method must be apparent to any one who has computed reactions analytically. Starting with a clean sheet of paper, the writer made the analysis shown in Fig. 1 and determined the reactions for unit loads at each of the 19 panel points in just seventy minutes. The results tabulated below show the degree of accuracy which was obtained with the small scale diagrams, the length of the arch rib being only about 13 inches. The flatness of the arch rib also decreased the size of z'' and increased the error.

Comparison of Graphical with True Theoretical Reactions.

Load at	z	H/P Graph.	H/P True.	Per cent. error.
1	19.3	0.306	0.3089	0.94
2	37.75	0.599	0.6084	1.54
3	55.25	0.878	0.8918	1.55
4	71.60	1.137	1.1511	1.23
5	85.75	1.361	1.3812	1.46
6	97.75	1.551	1.5759	1.58
7	107.5	1.719	1.7322	0.76
8	114.5	1.818	1.8457	1.50
9	119.1	1.891	1.9152	1.26
10	120.5	1.913	1.9381	1.29
	$z'' = 63.0$			

The horizontal reaction due to temperature change and rib shortening can also easily be computed. If d is the change in chord length of the arch rib due to any cause when the left end is on rollers (*i.e.*, unrestrained), then the H reaction required to return the end to its original position is $\frac{d}{\delta_{AA}}$ or

$$H = \frac{d E I}{z'' p \Delta s}.$$

Using the horizontal reaction influence line, the moment and shear influence lines for any section may be very readily drawn, as shown in Fig. 1, and the maximum moments and shears obtained from them. The influence line method of obtaining maximum stresses has the advantage of being simple and sufficiently accurate and the graphic representations are easily checked.

Deflection of Arch Rib.—Graphical methods of obtaining the deflection of arch ribs have been used, such as the method of Henry DeDion ("The Washington Bridge" by W. R. Hutton) and that explained by Mr. E. E. Howard, Pro.Am.Soc.C.E., May, 1915, but these methods are quite laborious and indirect. The y elastic curve of an arch rib under any load may be drawn directly just as it was drawn for the continuous beam in the previous article. Fig. 2 shows the elastic curve of the arch under consideration when loaded with equal panel loads at each of the seven central panel points. The reactions are found from the H influence line and the moment diagram is con-

structed. The arch rib is divided as before so that $\frac{\Delta s}{EI}$ is constant and the average moment for each division is laid off algebraically on the load line of the force polygon, positive moments downward and negative moments upward. The funicular polygon is constructed exactly as before and the ordinates between it and the straight closing line give the amount of rise or fall of every point on the neutral axis. The deflection is equal to

$$D = \Sigma''' P \frac{\Delta s}{EI}.$$

The elastic line in Fig. 2 shows how the rib sinks at the crown and rises near the haunches.

Effect of Horizontal or Oblique Load.—It is sometimes necessary to consider the effect of horizontal loading on an arch rib as in the case of the building arch shown in Fig. 3. The effect of oblique loads may be determined directly but it will usually be simpler to resolve them into horizontal and vertical components and determine their effect on the reactions separately.

The arch shown in Fig. 3 consists of columns hinged at the bottom and a segmental arch rib supporting beams and slabs. To determine the effect of horizontal loads, the rib and columns are divided up into small parts so that $\frac{\Delta s}{EI}$ is constant and the centre points of these divisions are projected horizontally as before. To determine the reactions under horizontal load, it is necessary to draw only one funicular polygon $A''B''C''$. The same theory is applied as before. The horizontal displacement at A produced by H must be equal to that produced by the horizontal force P acting at any point O again considering A on rollers, or as before

$$H_A = P\frac{\delta_{OA}}{\delta_{AA}}.$$

The x elastic curve for unit value of H is again constructed as in Fig. 1 from the expression $\Delta x = \frac{\Delta s}{EI} \sum y^2$. The x displacement of the point O relative to B is then equal to $\frac{z_O p \Delta s}{EI}$ and that of A is $\frac{z_A p \Delta s}{EI}$. The value of the left hand reaction is then

$$H = P\frac{z_O}{z_A}.$$

From this relation, the effect of any combination of horizontal loads can be easily determined. It is very interesting to note that if the funicular polygon be redrawn so that it passes through the end hinges and the centre crown point of the arch it becomes the reaction locus for concentrated horizontal loads and the reactions can be found directly from it, as shown in Fig. 3.

The graphical method of analysis outlined in this article will save an immense amount of time, particularly when applied to ribs which are in the least irregular, and it makes the analysis of two-hinged arches practically as simple as that of three-hinged arches. With slight modifications, the method may be applied to braced arches. Its practical value is shown by the fact that it was used to determine the stresses in the Hell Gate arch, the largest two-hinged arch in the world. One of its greatest advantages is that it at once gives influence lines for the reactions produced by a load at any point while an analytical solution is confined to one particular condition of loading and the solution must be repeated for each change in loading.

The graphical method may also be applied to fixed arches and the influence lines for thrust, shear and moment can easily be drawn. In the foregoing brief description it has not been possible to explain the theory in full, but the writer believes that the method can be readily understood by one who is familiar with the ordinary methods as given in the standard texts mentioned. When the graphical theory is once understood, the general application of the method is very simple.

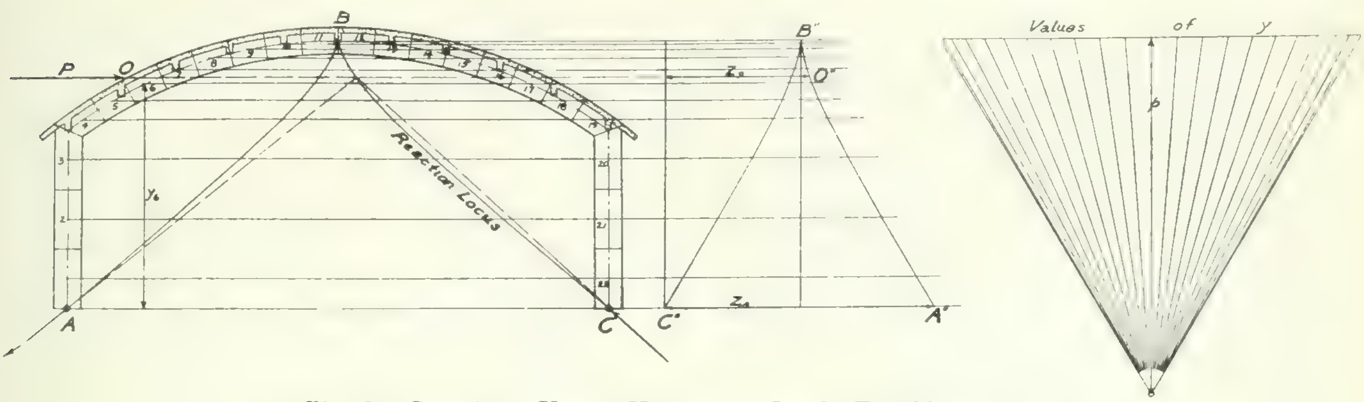

Fig. 3.—Reactions Under Horizontal Load—Two-hinged Arch.

In an action before a United States court for the value of colts struck by a freight train consisting of 10 cars not heavily loaded, and going at about 30 miles an hour, the evidence showed a reasonable effort to stop the train. The engineer testified as to braking power, but said it was very variable. The trial court held as a matter of law that the train could have been stopped within 600 or 650 feet. On appeal to a higher court, however, it was held that the finding of the trial court was in error as there was no positive testimony to sustain it.

The Canadian Fairbanks-Morse Company, Limited, have secured the sole rights in Canada for the Garrow Lamp for the use of contractors. This light is of 8,000 candle power capacity, and is made entirely of steel and cast iron, being welded by the oxy-acetylyne process. One important point of merit about the lamp is that it is possible to use this light in places such as tunnels without danger, as any excess gas that is generated cannot escape but is led to the burner and there ignited at the main flame, thus obviating the danger of gas being generated faster than it can be consumed.

The total number of persons killed from every cause on the railways of the United States during the year 1915 was 8,621, of whom 5,084 were trespassers. The number killed is the smallest since 1902, when 8,588 were killed, although now the mileage is 28 per cent. greater, the gross revenue, which represents traffic volume, 72 per cent. higher, the number of passengers 52 per cent. greater, the tonnage 61 per cent. greater, and 51 per cent. more men are employed.

PRICE OF "BLEACH" ADVANCING.

Waterworks officials and hydraulic and sanitary engineers are aware of the tremendous increase in the cost of calcium hypochlorite and liquid chlorine during the past eight months, and this increase has been viewed with alarm by those interested in the use of these chemicals for water purification purposes.

Practically all of the chlorine now manufactured is formed by the electrolytic decomposition of salt solutions, there being two by-products—chlorine gas and caustic soda.

Liquid chlorine is formed by drying and compressing the chlorine gas evolved from the electrolytic cell.

Calcium hypochlorite is formed by passing chlorine gas over lime, the lime absorbing the chlorine and acting merely as an inert "carrier."

The war is directly responsible for the increase. Over 50,000,000 pounds of calcium hypochlorite were imported annually by the United States and Canada from England and Germany, and a considerable part of such importations is used by waterworks.

The normal demand for bleach was considerably increased by the use of this material in certain new processes in the manufacture of explosives.

The supply of Canadian and American "bleach" available was not sufficient to meet the demand, and consequently the price increased. When quotations on hypochlorite reached the present figure, it was more profitable for the manufacturers to take the gas required to manufacture liquid chlorine and turn it into hypochlorite, rather than to compress and sell it as liquid chlorine. Therefore, the price of liquid chlorine also increased.

Eight months ago, hypochlorite sold for 1¾ cents to 2 cents per pound in small quantities and for 1½ cents per pound in carload lots. To-day it is bringing 12 cents to 14 cents per pound in small quantities and 11 cents to 12 cents per pound in carload lots.

Eight months ago, liquid chlorine sold for 10 cents per pound in small quantities and for 8 cents to 9 cents per pound in large shipments. To-day it is quoted at from 18 cents to 20 cents per pound on small quantities and 15 cents and upward per pound on large yearly contracts.

Both calcium hypochlorite and liquid chlorine are used in considerable quantities to accomplish bacterial purification of water supplies. Although the amounts so used form only a fraction of the quantities required in various industries, the waterworks demand for these materials is increasing continually.

In the manufacture of hypochlorite, the lime will only carry a certain percentage of its weight of chlorine—approximately one-third—so that to obtain one pound of chlorine for water purification, three pounds of hypochlorite must be used. Liquid chlorine is 100 per cent. pure chlorine.

Both calcium hypochlorite and liquid chlorine require special apparatus for their application to water supplies; hypochlorite apparatus being known as "hypochlorite dosing devices," and that for liquid chlorine as "chlorine control apparatus" or "chlorinators."

The Canadian Engineer is indebted for the above information to Messrs. Wallace and Tiernan, of New York City, manufacturers of chlorinators.

Hydraulic pressure for forcing antiseptics into wood was first used in 1831 by a Frenchman named Breant. He used a closed, vertical cylinder, in which the wood was placed upright on end and the pressure applied.

LETTER TO THE EDITOR.

Sir,—In connection with the editorial in your issue of April 13th concerning the status of the firm of Escher Wyss and Co., we would esteem it a great favor if you would publish the following facts in justice to our firm:—

Up to September, 1915, there was not the slightest doubt in Great Britain regarding the nationality of our firm. A great number of orders from the British and Allied Governments were placed with us and executed until the trouble started through the denunciations of one of our competitors. Immediately, our directors took the necessary steps, through the Swiss Legation in London and the British Consulate in Switzerland, to institute an official investigation. The British and the Canadian Governments were requested through the Embassy in London and the Swiss Consul-General in Montreal, respectively, to suspend any action until the investigation was concluded. The name of our firm was in the meantime placed on the "Suspensory 'B' List."

The investigation was carried out by a British delegate on behalf of the Foreign Office, and as soon as his report reached the Foreign Trade Department, we were informed officially by Sir Edward Grey that no further objections to our firm would be entertained. The Canadian Government, unfortunately, was not informed of this fact until February of this year through the Canadian High Commissioner in London.

While the denunciations have caused both our works and ourselves considerable annoyance and loss of business, it has, on the other hand, enabled us to obtain an official investigation and subsequent declaration which will undoubtedly satisfy any of our customers who may have been doubtful regarding our status. The majority of our customers have always been satisfied with our statements, as the number of contracts obtained by us since the commencement of the war prove conclusively.

ESCHER WYSS & CO.,
Head Office for Canada.
Th. Seidl, Chief Engineer.

Montreal, April 17th, 1916.

RAILROAD EARNINGS.

The following are the railroad earnings for the first week of April:—

Canadian Pacific Railway.

	1916.	1915.	
April 7	$2,482,000	$1,766,000	+ $716,000
April 14	2,577,000	1,701,000	+ 876,000

Grand Trunk Railway.

April 7	$1,155,486	$1,008,320	+ $147,166
April 14	1,024,505	864,058	+ 159,847

Canadian Northern Railway.

April 7	$ 677,000	$ 457,000	+ $220,000
April 14	668,900	463,700	+ 205,200

According to the annual blue book of the Railway Department giving telephone statistics, there is now one telephone for every 15.1 persons in Canada. The increase in the use of the telephone has been steady during the past few years, and war conditions do not seem to have interrupted the progress. The number of telephones reported as being in use in 1915 was 533,090, an increase of 11,946 over 1914. The principal growth was in rural districts. The net earnings of the 1,396 companies in Canada totalled $4,764,957, which was $350,091 better than the result of 1914. The total capitalization of Canadian telephone companies now amounts to $74,285,000.

AMERICAN RAILROAD BRIDGES.*

AMERICAN railroad bridges as now constructed are the results of an evolution, during the course of which many types found to be undesirable were abandoned; some types found to be good were maintained and new features and types were introduced, until, finally, the 1915 standards represent the culmination, at the end of more than three-quarters of a century of railroad bridge history. During the first period, extending to 1865, there was no real science of proportioning members and the best that builders could do was to be guided by judgment based on experiment or precedent, and to make all new bridges stronger than before. During the second period, 1865 to 1890, scientific designing became general and the typical American railroad bridge, "a skeleton structure pin-connected at all the principal articulations," was brought to a fair state of development. The present standards were essentially developed during the third period, 1890 to 1915. The scope of the present sketch will be confined to the third period, ending in 1915.

Naturally, the trend of improvements in bridge construction has been controlled by a number of definite influences, some of which are still in operation, and will undoubtedly continue long into the future. American railroad bridges, therefore, although substantial, economical and durable, are still in a state of development, the final culmination of which cannot as yet be foretold. The most persistent of these influences has been the constantly increasing weight of rolling loads. It has far exceeded anything which was anticipated in the past, and has been the direct cause of the renewal of many bridges which would have been still serviceable under the loads for which they were designed.

All of the earlier types of patented bridges were tested in service to the full extent of their capacity and endurance and it was observed that while they were good enough for the light loads and traffic of their day, their flimsiness, due to the inherent defects of their designs, and their action under traffic made them very unsatisfactory structures for heavier loads. They, therefore, became obsolete and were replaced by the improved types of single-intersection, pin-connected trusses, and by riveted, lattice and plate girders, which were evidently much superior and which had been developed to such a state of perfection by the year 1890 that engineers believed they had established standards of design which would endure. These more modern bridges have also been tested in service under increasing loads to the full extent of their capacity, as was the case with the earlier bridges, and it has been learned that, while these later bridges were also well adapted to the traffic of their day, their designs embodied features and details which prevented them giving long and satisfactory service under the heavier loads which were constantly being placed upon them. The trusses had too many adjustable members and light bars to shake loose, too many hinged joints to wear away, and too much motion of parts to inspire confidence under the fast speed of heavy engines and trains. The necessity for less looseness and greater stiffness became apparent, and it was found that when the flimsy, adjustable bracing was replaced with stiff bracing with riveted connections, and the shaky eye-bars were tied together so as to reduce motion, the stiffened structure gave much more satisfactory service. Therefore, the effects of the influence of the constantly increasing loads on railroad bridge development is evidenced by the elimination of adjustable members and short span trusses, and by the general stability and solidity of construction which are the essential characteristics of present standards.

Another influence in American bridge development has been the introduction of new materials of construction. In the old abandoned types, wrought iron rods or links were used generally for tension, and wood or cast iron for compression members. The substitution of wrought iron for the cast iron and wood enabled the construction of the improved types which were standard in 1890, and which had details and connections far superior to anything which could be obtained by the use of cast iron or wood. Since 1890, rolled structural steel has entirely supplanted wrought iron in metal bridge work, and on account of its greater strength and economy it has had an influence on the construction of longer lengths of spans, both in girders and in trusses, than were attempted with wrought iron. The standard structural steel, at the present time, has an ultimate strength averaging about 60,000 lbs.; and the longest simple span so far constructed of it is 620 ft. This span is in the Kentucky and Indiana Terminal Railroad Company's bridge across the Ohio River at Louisville, built in 1912.

Alloys and special steels, with much greater strength than standard structural steel, are now used in long-span

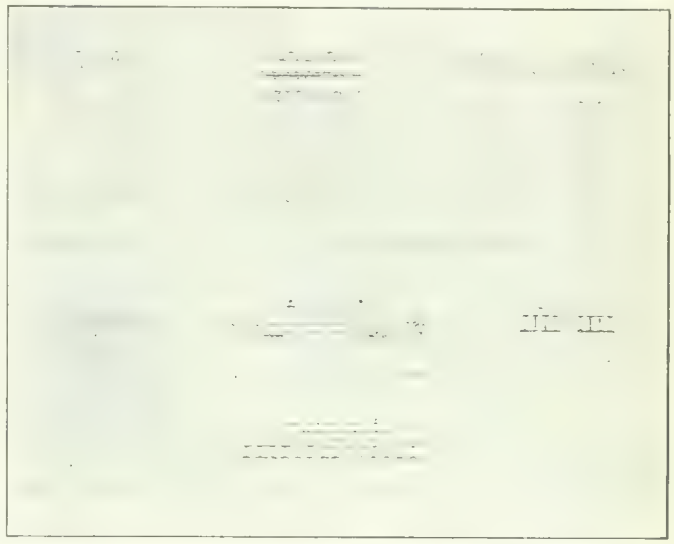

Fig. 1.—Trestle and I-Beam Bridges of 1890-1915.

trusses for the purpose of keeping the dimensions and weights of members within the limits of commercial and economical production. For instance, nickel steel was used in the construction of 668-ft. spans of the Municipal Bridge at St. Louis, built in 1912. Nickel steel eye-bars and so-called silicon steel compression members will be used in the Ohio River Bridge at Metropolis, the longest span being 725 ft.; high carbon steel is used in the 977.5-ft. span of the Hell Gate Bridge; and Mayari steel, which contains nickel, and is made from the Mayari ore from the north coast of Cuba, is being used in the construction of a large bridge which is to span the Mississippi River at Memphis. These alloys and special steels have not, as yet, exerted any material influence on the development of railroad bridges, except, perhaps, in the direction of greater span lengths than can be economically, or even practically, constructed of the standard structural steel.

A material which has come into general use during the past few years is reinforced concrete. It has had a very decided effect on bridge development, since it has influenced the adoption of a new type of short-span bridge having a ballasted deck and a solidity of construction with

*Abstract from a paper read by J. E. Greiner, M.Am.Soc. C.E., at the International Engineering Congress.

an economy impossible to be obtained by the use of any other available material.

Another influence on bridge development is the improvement in tools and machinery, especially in pneumatic tools and self-propelling erection derricks. Pneumatic drills, reamers and riveters are now generally used in erection work in place of the old-time hand tools, and has a consequence, field-riveted connections are no longer avoided, as was the case in 1890, since they can now be easily and quickly made. By the use of self-propelling erecting derricks, plate girders and bridge members of a weight far beyond what was formerly practicable can now be handled and erected with safety, facility and economy.

At the beginning of the period (1890), pile and framed timber trestles were being constructed on main lines. The design differed in no material respect from the earliest types, except as to number and dimensions of timbers, the floor deck being composed of cross-ties resting on groups of timber joists. In suitable locations, they were economical, easy to maintain under their light traffic and regarded as all-sufficient for the purpose. Howe truss bridges were also being built on main lines of some roads.

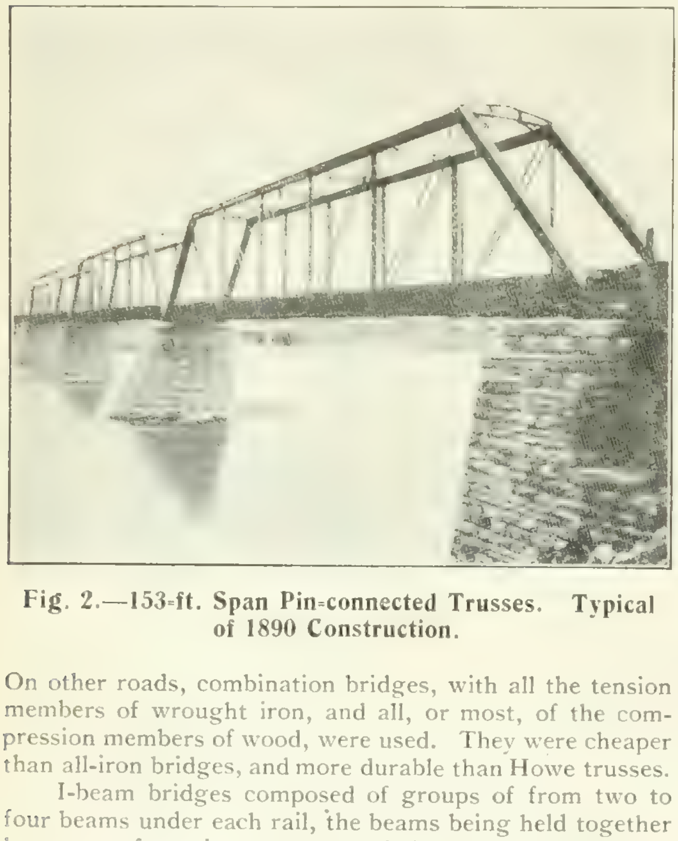

Fig. 2.—153-ft. Span Pin-connected Trusses. Typical of 1890 Construction.

On other roads, combination bridges, with all the tension members of wrought iron, and all, or most, of the compression members of wood, were used. They were cheaper than all-iron bridges, and more durable than Howe trusses.

I-beam bridges composed of groups of from two to four beams under each rail, the beams being held together by means of cast iron separators bolted between the webs, and with cross-ties resting directly on the upper flanges of the beams, were commonly used for spans having a length of from 10 to 20 ft. Plate girders were acceptable for spans up to 65 ft., which was about the limit for economical construction and handling, although some few roads constructed girders of a greater length. Single or double intersection riveted low truss bridges, or latticed girders, as they were called, were used for spans between 65 ft. and 100 ft., and in some cases up to 120 ft.; but the longer spans were not acceptable to many engineers on account of the inability to ship the trusses in one piece and the necessity of so much field riveting of important connections, and the increased risks and cost of erection. For spans over 100 ft. the practice, with very few exceptions, was to construct trusses of the pin-connected type. The principal characteristics, in addition to the pin-connections, being the minimum ambiguity of strains, the concentration of parts, facility of manufacture, perfection of length and fitting of all the members, a minimum of riveting and mechanical work in the field, and the readiness with which the individual members can be assembled during erection. Typical American railway viaducts, with 30-ft. towers and 30-ft. or 60-ft. free spans, were regarded favorably. Movable bridges were of the swing type, revolving in a horizontal plane on a centre pier. Lateral bracing for truss bridges, viaducts and in many through plate girders had adjustable rods for the tension members and the counters in truss bridges were also made adjustable. Wrought iron was still used for built-up members, but eye-bars and wide web-plates of girders were generally made of soft steel.

Bridge piers and abutments were generally of cut stone masonry construction, and arches were of cut stone work throughout or had their rings made of brickwork. The arch was then recognized (as it is now) as the very best type of railroad bridge, but cut stone work was very expensive in first cost as compared with steel, and as a consequence relatively few arch bridges were being built.

Nearly every railroad in America constructed its bridges in accordance with specifications peculiar to the individual road; consequently, there were practically as many kinds of bridge specifications as there were important railroads. The makers desired to be thought original, and therefore displayed their ingenuity in those parts of bridge specifications that gave them the most leeway, *viz.*, in the permissible working stresses, column formulas, grades of steel, impacts and in the typical engines used as a basis for proportioning. In these numerous specifications every conceivable kind of typical locomotives was specified, some with practically the same total weight, but with a different distribution of loads on the wheels and a different wheel spacing. There were no generally recognized standards for loading, impact allowances, permissible working stresses, or for the quality of material used and methods of testing same. Contracts were based on a total price for the completed work, and as the total price depended largely on the amount of material which entered into the construction, successful competition frequently depended upon a design which gave the lightest possible structure.

At the close of this period (1915) open deck framed timber trestles are seldom built except on light traffic or branch lines or as temporary expedients, with the expectation of replacing them with permanent structures in a short time. In many sections good timbers can no longer be obtained except at excessive cost; the general upkeep is expensive and they are an undesirable type for heavy loading. Some roads now build wooden trestles of a different type, inasmuch as they have ballasted decks on solid timber flooring and are constructed of creosoted timbers. These modern types are more durable and easier to maintain than the old open-deck structures and represent the best practice for timber trestle construction, but they cannot as yet be considered as general standards. Some western railroads are replacing timber trestles with a type made of reinforced concrete with ballasted decks. This is a distinctive type as compared with the trestles of 1890. Howe truss bridges and combination bridges are no longer constructed, except in very isolated cases or on unimportant branches. They are ill-suited for heavy loading and good timbers are difficult to obtain.

I-beam bridges as now constructed are generally encased in concrete. Open decks with wooden cross-ties are avoided, stone ballast on concrete being used as a sub-

stitute; and on some roads short spans are reinforced concrete girders or slabs. Plate girders are being built and shipped in one piece in spans up to 120 ft, and, in some cases, of even longer length; the ability of the railroad companies which handle them being still the governing condition. Shipping conditions require a limit in the depth of these girders to about 10 ft., and for this depth they are now more economical than riveted trusses of the same depth for spans between 100 ft. and 120 ft. The standard practice in regard to riveted trusses is to use them for spans between 120 ft. and 200 ft., although much longer

Fig. 3.—620-ft. Span Pin-connected Trusses. Typical of 1915 Construction.

spans are built. The pin-connected truss bridges may still be considered typical of American practice, but only for spans greater than 200 ft. Many of the characteristics which were so favorable to the construction of this type in 1890 are no longer peculiar to it, since the improvements in tools and machinery and in methods of handling and doing the work now enable the construction of riveted bridges having practically all the good characteristics of pin-connected structures, with the exception of the number of rivets, and this is no longer an objectionable feature. Riveted trusses have the additional favorable characteristic in the harmonious working of the various sections and parts of members, a condition which is not always obtained in the pin-connected type. The superiority of the riveted truss, which for a long time has been recognized in Europe, is now quite generally conceded by American railway bridge engineers, except for spans of such lengths as to require riveted connections to be too cumbersome for practical and effective construction. The typical American railway viaduct, with its steel towers, is still considered a good type when all bracing is stiff; but concrete piers, in a number of cases, have been constructed in preference to the steel towers, since they are less expensive to maintain, and, in favorable locations, are not much more expensive in first cost.

Swing bridges, revolving in a horizontal plane, are still being constructed; as are several patented types of bascule bridges, revolving in vertical planes. Another recent type of movable bridge is hauled up and down with wire ropes and counterbalanced by masses of concrete suspended over the tracks from steel cables. These are special types designed to compete with bascule bridges, and there are some locations and conditions which are particularly favorable to their construction.

All lateral bracing is now made of stiff members with riveted connections. Adjustable members, even for counters, are preferably avoided; and metal bridges are entirely of steel, wrought iron having for a number of years past been an uncommercial product for bridge construction. Open decks, with cross-ties resting directly on top flanges of beams or girders, while still used to a considerable extent, are undesirable for short spans under the present heavy traffic; the preference being for a solid ballasted deck, so as to maintain a continuous ballasted road bed.

Monolithic concrete masonry with a few rods imbedded for tying the mass has practically replaced cut stone work for piers and abutments; and reinforced concrete arches are replacing short-span steel bridges and stone arches, since the cost of this type of bridge, in locations suitable for its construction, is but little more than the cost of a steel bridge with a solid floor, and in many cases the cost may be even less.

In regard to present tendencies, it may be stated that the introduction of new grades of structural steel and the improvements in machinery and in methods of construction are still influences to be considered in future developments. There is a tendency toward the use of alloys with high ultimate strength in the long-span bridges, and when these new materials inspire general confidence in their uniformity and reliability for lighter work and their production commercially becomes less expensive, they may gradually replace the present standard structural steel, just as the latter has superseded wrought iron. This, in turn, may require some different types of metal bridges to be designed, so as to take advantage of the greater strength of the metal without sacrificing stiffness in the structure as a whole; or perhaps the present quality of stiffness in metal structures will give place to more elasticity. Another tendency is toward the use of reinforced concrete construction in preference to steel work wherever the conditions are suitable for this type of bridge, and toward continuous ballasted roadbeds over all bridges. There is also a tendency toward the construction of movable bridges revolving in vertical planes instead of in horizontal planes.

These tendencies indicate that the evolution of the American railroad bridges has not as yet reached its final stage, but is still in progress under influences which will continue to direct its trend toward meeting changes in physical and economic conditions.

Fig. 4.—Viaduct with Steel Towers. Typical of 1915 Construction.

In conclusion, it may be stated that the recent improvements in American railway bridge practice embrace the substitution of solid-ballasted decks for open decks on short-span, beam-girder bridges and for trestles; of plate girders for short-span, riveted trusses; of riveted trusses for short-span, pin-connected trusses; of stiff bracing and counters for adjustable members; and of concrete and reinforced concrete masonry for cut stone work. While a few years ago the dominating characteristics of American railroad bridge construction were lightness, flimsiness and cheapness, the characteristics of the present-day standards are stability, solidity and permanence.

PRECISE LEVELLING BY THE GEODETIC SURVEY.*

By F. B. Reid, D.L.S., Supervisor of Levelling.

(Concluded from last issue.)

"On all sections upon which the forward and backward measures differ by more than $0'.017\sqrt{M}$ (M being the distance in miles between adjacent bench marks) both the forward and backward measures are to be repeated until the difference between two such measures falls within the limit. No one of the questioned measures is to be used with a new measure in order to get this agreement. In this way, four, six or more measures are made, the mean of all being taken and the individual residuals determined. Reject all measures whose residuals are greater than $0'.017\sqrt{M}$; then take a mean of all remaining forward measures for a final forward result and a mean of all remaining backward measures for a final backward result. . . .

"No rejection shall be made on account of a residual smaller than aforesaid unless there is some other good reason for suspecting an error in this particular measure, and in such case the reason for rejection must be stated in the record.

"Between two adjacent permanent bench marks the same rule as to agreement of forward and backward levelling is to be applied; consequently it may be necessary, at times, to relevel sections which are themselves within the allowable limit of error in order to bring the longer section between permanent benches within such limit. . . .

"When a blunder is discovered, such as a misreading of one foot or one-tenth, or an interchange of sights (a backsight being recorded as a foresight, the correction should be made by recovering the old turning points and making the readings anew. The figures in error should then be struck out (not erased) and the correct figures inserted, the leveller initialing the change. . . . In the event of one or more blunders being discovered in both the forward and backward measures of a section, or in any other case in which there is any uncertainty whatever, the leveller is to follow the safe course and relevel the section in one direction after the corrections have been made.

"If, in the progress of the work, the difference between the forward and backward levelling shows a constant tendency as to sign, the leveller should not spend time relevelling sections which are themselves within the allowable limit in an effort to reduce the total discrepancy. He must rather look for the source of trouble in his general program of observations and in the habits of the rodmen.

"The daily mileage is influenced very largely by the length of sight; but if a leveller, through desire to make rapid progress, attempts to read farther than he should, the thread intervals will become irregular and his relevelling will probably be excessive. In any case the work will not be of a precise nature. . . .

"The line of sight must be removed as far as possible from the abnormal boiling of the atmosphere near the ground. In this connection especial care must be exercised when levelling along grades since the rod readings in one direction are necessarily nearer the ground than those in the other. The unequal refraction of the lines of sight will then tend to introduce a systematic error in the results, which is all the more serious since it will not be apparent if the levelling in the two directions is done under similar atmospheric conditions. If any unsteadiness in definition is noticeable, the rod reading of the lowest thread should never be within one foot of the ground. This will often mean shortening the sights considerably, but it must not be forgotten that, though speed is desirable, the work is of a precise nature and results of the highest order are of the first importance."

The requirement that the discrepancy between forward and backward levelling shall be within $0'.017\sqrt{\text{distance}}$ in miles has been adhered to as closely as possible throughout the work. This means that for 1 mile the forward and backward shall correspond within $0'.017$, for 4 miles within $0'.034$, for 100 miles within $0'.170$, and so on. Quite frequently the total discrepancy of a line shows a constant, and often unaccountable tendency to accumulate in one direction; that is to say, the up-hill runnings persistently give larger results than the down-hill runnings, or vice versâ, without regard to whether the up-hill running happens to constitute forward levelling or backward levelling. Various precautions are used to guard against this. If, when reading from the successive instrument stations or set-up points, the rear rod were always read first, and the forward rod last, any settlement of the level between the backsight and foresight would have a constant tendency to make the foresights too small, and on the backward levelling this effect would be repeated, causing the discrepancy between the two runnings to accumulate rapidly. This is obviated by reading on the rear rod first at one station and on the forward rod first at the next station, so that any settlement at one will be counteracted by the settlement at the next. This method also has the advantage of eliminating the effect of a uniformly changing refraction in the atmosphere, such as usually occurs most noticeably in the early morning and late afternoon hours. It, of course, has the effect of holding back the progress of the work considerably, as at every second set-up the leveller has to wait for the front rodman to reach his turning point, and afterwards wait for the rear rodman to overtake him before going forward.

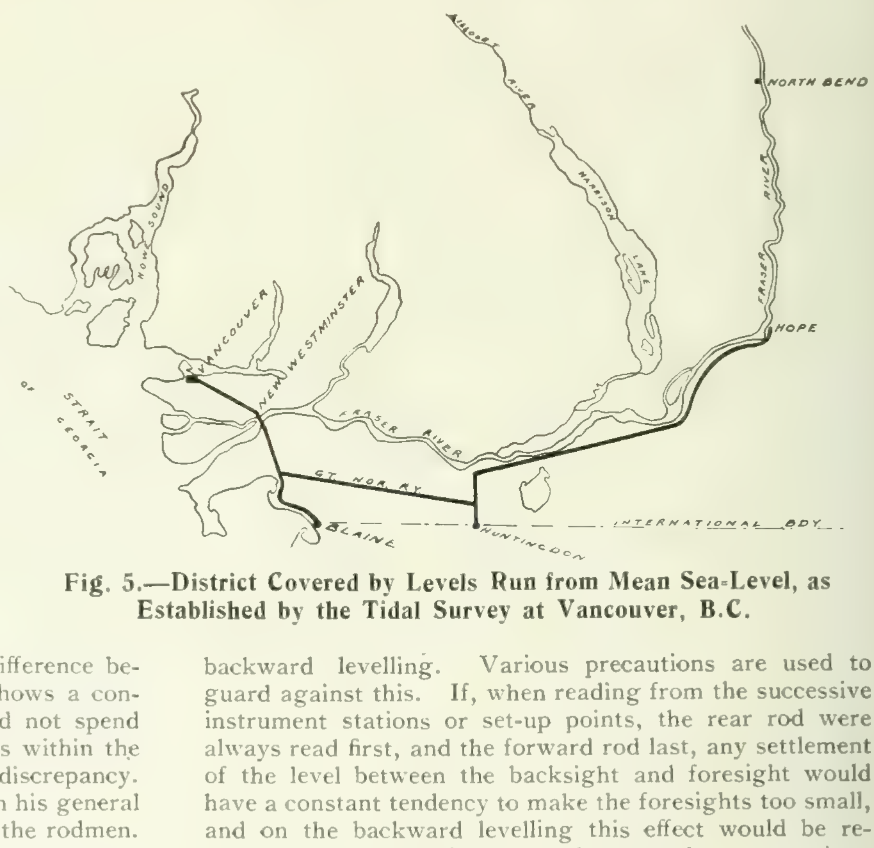

Fig. 5.—District Covered by Levels Run from Mean Sea-Level, as Established by the Tidal Survey at Vancouver, B.C.

*Read before the Royal Astronomical Society of Canada, at Ottawa, March [illegible], 1916.

Another source of error would be a systematic rising or settling of the rod supports. This would have a similar effect to the movement of the level, and cannot be guarded against in the same way. It is essential that rod supports should be as solid and immovable as possible. In running along a railway the most solid supports are also the most convenient, namely, the top of the rails. The rodman holds the rod with its semi-circular knob on a cross made on top of the rail, about midway between the rail joints. This has been found to be more satisfactory for a turning point than anything else. Upon a track in ordinary condition the passing of a train appears to have no effect. The rail may rise and fall an inch or more under the passage of the wheels, but careful comparison of the elevation of the point on the rail with some solid point to one side, before and after a train has passed, shows that the rail returns to sensibly the same elevation. Of course, when the track has been freshly ballasted and is, consequently, likely to settle down under a train, a turning point is taken to one side when a train is known to be approaching. When following a highway, as when running branch lines into a town, suitable steel pins, driven solidly into the ground, are used. The verticality of the rod, while readings are in progress, is maintained by means of a small spirit level.

Regarding the paragraph in the instructions which deals with levelling along grades, it is evident that when running up a steep grade the point read on the forward rod is much nearer the ground than on the rear rod, consequently the effect of refraction, or boiling of the atmosphere, is to distort the foresights more than the backsights. By taking very short sights, and thus keeping the line of sight away from the ground as much as possible, the effect is minimized but not by any means eliminated. The only way to do the latter would be to wait for cool, cloudy weather, when there is no perceptible refraction—which is not usually practicable. If one makes the forward levelling in such weather and the backward in a bright, hot sun, or vice versâ, the discrepancy is usually very noticeable. If both measures were made under the unfavorable conditions the results would probably show a good accordance, but both would be in error. This error would be compensated on the next down grade only if the weather conditions were similar. Atmospheric refraction affects the readings on the levelling rods most noticeably in two ways: Firstly, when the ground is being rapidly heated by the rays of the rising sun, the lowest stratum of air becomes, in its turn, heated by the ground and begins to flow upward. This has the effect of making the readings appear to rise and fall vertically, and even to remain for a minute or so in quite abnormal positions. Such conditions are unsuitable for observations. Secondly, when the air is bubbling, the graduations on the rods appear to dance or vibrate; they are then difficult to subdivide, but no systematic error is to be feared.

The length of sight taken depends upon the atmospheric conditions. Under the influence of a bright sun, without any breeze, especially when following a cold night, the boiling of the atmosphere is so severe that the divisions on the rod often cannot be subdivided with accuracy at a greater distance than 200 feet. Under average conditions sights vary from 300 to 400 feet. On a very favorable day these may be lengthened to 500 or 550 feet, or even more. The above remarks apply, naturally, to a level, or almost level, track. On a 2 per cent. grade, sights of 200 feet could not safely be exceeded in the best of weather.

The average progress for one month's work should be 60 or 65 miles of completed line. The amount of re-levelling required should not amount to more than 10 or 12 per cent., provided weather conditions are at all favorable.

This class of work is so dependent for speed and precision upon the weather that it is found necessary to discontinue it in the autumn when the weather gets cold and storms become prevalent.

When carrying the line of levels along the railways the elevation of the top of the rail is taken opposite each station and at the crossings of intersecting railways, whether diamond, overhead or under crossings; in the latter cases, the distance to the rail of the intersecting railway is measured with a tape. When rivers or arms of lakes are crossed by bridges the rail level is taken on the bridge and the distance to the water measured. The rail elevations are tabulated in the office in a separate form of record from the bench marks and are useful as giving permanent records of the work in addition to those furnished by the bench marks. They are also very useful to the companies, since they furnish a means of comparing their profiles with our levels without the necessity of making any actual connections on the ground as would be necessary in the case of bench marks.

The elevations furnished in this way are only tabulated to the nearest tenth of a foot. They furnish a very practical record, nevertheless, and are in demand by engineers and others.

When the final elevations for the junction points have been fixed by an adjustment by the method of least squares or other means, the new elevations for the intermediate points may be fixed by interpolating between the junction points. The results thus obtained will be satisfactory only until more levelling is performed and still more circuits are introduced into the net, thus upsetting to a greater or less degree the results of the adjustment.

Regarding the precise level net of the United States the following paragraph from the report of the Coast and Geodetic Survey on the fourth (or 1912) general adjustment will be of interest: "When extensive additions are made to the precise level net of the country a readjustment of the level net must be made in order to obtain the best practicable elevations of bench marks and to eliminate the differences in the elevation of a bench mark which is on several lines of levels. Theoretically, the best method of procedure is to readjust the entire net and not to hold fixed any elevations resulting from the previous adjustment. This method, however, is impracticable, for the surveyors, engineers, and others whose operations are based on the elevations furnished by the precise levelling, wish to have the elevations used in any particular case held as fixed for an indefinite period or for all time."

The following plan was adopted in the 1912 adjustment: An adjustment of the entire net was made, then a comparison was made of the elevations resulting from that adjustment and from the last previous (or 1907) adjustment. This showed that the elevations of the bench marks lying to the eastward of an imaginary line running (approximately) from the middle of Lake Superior to the Gulf of Mexico near New Orleans might he held without change. Sixty-nine junction points were enabled to be held and of these only 14 had a difference of more than one-third of a foot from the elevations given by the new adjustment. A special adjustment was then made which included that portion of the net to the westward of the imaginary line mentioned above. "The elevations in the western part of the country resulting from the special adjustment and those held from the 1907 adjustment in the eastern part of the country are assumed to be standard

elevations and are expected to be held without change. It is believed that the precise levelling net is sufficiently extended and of such strength that this may be done and that any new levelling in the future can be fitted to the standard elevations."

Quoting now from Special Publication No. 22 of the Coast and Geodetic Survey: "From time to time in the future, general adjustments of the level net will no doubt be made in order to obtain the theoretically best elevations of the junction points; but such adjustments will not disturb the standard elevations, unless they are found to be greatly in error on account of blunders in the levelling or due to the rising or settling of the bench marks from earthquake disturbances or the operations of man."

In India, where a system of levelling has been carried on since 1858, a complete report was published a few years ago by the Great Triangulation Survey. This gives the results of a thorough adjustment of all precise levelling up to 1909 by the method of least squares. Before this publication, arbitrary methods of adjustment were adopted, in most cases by giving infinite weight to the older lines and then fitting the new levelling into the old. So great discrepancies arose, however, that a complete readjustment, by a scientific method, was found to be necessary.

No adjustment has as yet been made of our system of levels in Canada. While a very considerable mileage has been levelled, it is, nevertheless, pretty well scattered all across the country and many additions to the system are still contemplated in each of the provinces. In view of this and of the rapidity with which new lines are being completed and new circuits closed, it would be premature at the present time to make an adjustment, only to have it upset in the near future. Fifteen circuits have, up to the present, been closed.

One of these circuits had a perimeter of 1,184 miles and a closing error of 1.285 feet, giving a closing error per mile of .00109 feet. The lengths of the other circuits ranged from 14 miles to 697 miles and the closing errors per mile from .00025 to .00503.

One circuit is composed of two lines starting from the village of Kipp, Alta. Both are carried over the summit of the Rocky Mountains, one via Calgary and the Kicking Horse Pass, the other via the more southerly route through the Crows Nest Pass. Coming together at the town of Golden, B.C., the two lines give elevations for the junction bench mark differing by less than 1½ inches, the total distance around the circuit being 623 miles. No one, of course, would be justified in saying that this result was due entirely to the accuracy of the levelling, which, by the way, was done by two different levellers working independently. No doubt errors counterbalancing one another have a good deal to do with it.

Progress and Publication of Results.—Levelling operations have been carried on each year by the Geodetic Survey since 1906. During the last two seasons six parties were in the field, while during the two seasons previous to that (*i.e.*, 1912 and 1913) four were employed. The total amount of levelling accomplished to date is 8,405 miles; that is to say, this distance has been run forward and the same distance backward, no account being taken of re-levelling. Of the above amount a little over 1,800 miles was done during the season of 1915. This is considerably the largest amount so far in one season. Two thousand three hundred and seventy permanent bench marks have been established, all being of the copper-bolt variety described earlier in this paper.

In order to give the public the benefit of our work, publications have been issued in pamphlet form each winter for the past four years. These give the results of the levelling in the different parts of the country as far as they are ready for publication and also include an index and map which are revised each year to indicate both the new work and that previously published.

For reasons previously stated, the elevations are not adjusted before publication. Where a new line is closed upon a previously published line the amount of the closing error is clearly shown so that anyone using the elevations will have evidence of the degree of precision obtained. Further, it is an easy matter to make a correction, equal in amount to the closing error, to any bench marks in the immediate vicinity of the junction point.

ORGANIZATION OF THE HYDROMETRIC SURVEY.*

The chief features of the stream measurement work are the collection of data relating to the flow of surface waters and a study of the conditions affecting this flow. Information is also collected concerning river profiles, the duration and magnitude of floods, irrigation, water-power, storage, seepage, etc., which may be of use in hydrometric studies.

This information is obtained by a series of observations at regular gauging stations, which are established at suitable points. The selection of sites for these gauging stations and their maintenance depend largely upon the physical features and needs of the locality. If water is to be used for irrigation purposes the summer flow receives special attention; where it is required for power purposes, it becomes necessary to determine the minimum flow; if water is to be stored, information is obtained regarding the maximum flow. In all cases the duration of the different stages of the streams is recorded. Throughout the country gauging stations are maintained for general statistical purposes to show the conditions existing through long periods. They are also used as primary stations, and their records in connection with short series of measurements will serve as bases for estimating the flow at other points in the drainage basin. Local residents are engaged to observe the gauge heights at regular stations. These observations are recorded in a book supplied by the department, and at the end of each week the observer copies the week's records on a postal card, which he forwards to the Calgary office by the first convenient mail.

District hydrometric engineers make regular visits to the gauging stations, usually once in every three weeks. On these visits they examine the observers' records, make discharge measurements, and collect such information and data as would be of use in making estimates of the daily flow at the station. The results of the discharge measurements and all data collected are forwarded as soon as possible after being completed to the Calgary office, where all reports are copied on regular forms and filed.

During the winter no records are taken at a number of the gauging stations, which makes it possible to reduce the field staff and have each engineer spend some time in the office and assist in the final computations and estimates of run-off. As far as possible, the same engineer that did the field work makes or checks the office com-

*From the report of Progress of Stream Measurements, 1914, by P. M. Sauder, G. H. Whyte and G. R. Elliott.

putations, so as to eliminate any chance of error through lack of knowledge of the conditions at the gauging station.

Gauge height-area, gauge height-mean velocity, and gauge height-discharge curves are plotted and rating tables constructed. Tables of discharge measurements, daily gauge height and discharge, and monthly discharges are also compiled. These records have been collected and are embodied in the Sixth Annual Report of Progress of Stream Measurements.

The staff consists of the chief hydrometric engineer, two assistant engineers, one recorder, one computer, and one clerk in the office, and thirteen assistant engineers in the field.

During 1914 the territory was divided for administrative purposes into eleven districts, viz., Banff, Calgary, Macleod, Cardston, Milk River, Western Cypress Hills, Eastern Cypress Hills, Wood Mountain, Saskatoon, Edmonton and Athabaska. In each district there was one engineer, who while in the field employed temporary assistance and was equipped with the necessary gauging and surveying instruments. In Banff, Calgary, Macleod, Saskatoon, Edmonton and Athabaska districts the engineers travelled by train and hired livery, and stopped at hotels and stopping-houses; while in the other districts they were supplied with a team, democrat and camping outfit.

During the open-water season of 1914 records were taken at one hundred and seventy-four regular gauging stations on various streams in Alberta and Saskatchewan, and at sixty-five regular gauging stations on irrigation ditches and canals. Winter records, which are so valuable for power investigations and municipal water supplies, received special attention, and records were secured on almost all the important streams in the two provinces throughout the year.

Special investigations, which were commenced in 1913 to determine the absorption and seepage losses in canals, have been continued. The officials of the Canadian Pacific Railway and the Alberta Railway and Irrigation Company have assisted the engineers of the government considerably in work done on the irrigation tracts of their respective companies. In addition to measuring the flow of the canals, the temperature of the water has also been taken. Results of these observations will produce valuable data in a few years.

The current-meter rating station, which is located at Calgary, has rendered valuable service not only to the Hydrometric Survey, but to the British Columbia Government, the Manitoba Hydrographic Survey, the Department of Public Works of Canada, and to the Canadian Pacific Railway Company.

Each meter is rated before being used, in order to determine the relation between the revolutions of the wheel and the velocity of the water. The meter is driven at a uniform rate of speed through still water for a given distance, and the number of revolutions of the wheel and the time are recorded. From this data the number of revolutions per second and the corresponding velocity per second are computed. Tests are made for speeds varying from the slowest which will cause the wheel to revolve to several feet per second. The results of these runs, when plotted with revolutions per second as abscissae, and velocity in feet per second as ordinates, locate points that define the meter rating-curve, which for all meters is practically a straight line. From this curve a meter rating table is prepared. Theoretically, the rating for all meters of the same make and type should be the same, but as the result of slight variations in construction and in the bearing of the wheel on the axis at different velocities the ratings differ.

After a meter has been in use for some time the cups may have received small injuries, or the bearing of the wheel on the axis may have changed owing to unavoidable rough usage. These changes will affect the running of the meter and change its rating. As a consequence, each meter is re-rated at regular intervals and a new rating curve and table prepared. Rating tables are prepared for each rating of a meter and blueprints made, which are sent out with the instrument, while the originals are filed for reference in the office.

In addition to the regular work a few experiments on rating meters have been carried out. These gave results which will be of assistance in future rating and field work. It is the intention, however, to make further and more extensive investigations before publishing the results.

When the stream measurement work was first started the gauges were usually referred to bench-marks on wooden stakes or stumps of trees. These were easily shifted or destroyed, and were not satisfactory. In 1911

View of the Car at the Current Meter Rating Station at Calgary, Alberta, Showing the Apparatus for Suspending the Current Meter in the Tank.

an iron bench-mark was adopted by the branch, and now almost all the gauges are either referred to bench-marks on concrete piers or other permanent structures, or to one of these iron bench-marks. Whenever an opportunity is afforded, these are tied to the Canadian Pacific Railway or Dominion Government levels, to determine their elevation above sea level, and they are, therefore, also a convenient reference for local levelling operations.

As above intimated, the reports of the gauge-height observers and the hydrometric engineers are transmitted to the office by mail. These are copied on office forms and filed in a cabinet, which is carefully indexed, and where they can be referred to at any time without trouble. As the engineers complete their computations, the results are entered on convenient forms and filed in the same cabinet.

A cabinet made up of four styles of drawers is used for filing the records. The top section is used for filing the gauge height books of the observers and the current meter notes of the engineers. The gauge height books and current meter notes are filed alphabetically, according to the names of the streams. The next section contains the postal cards sent in by the observers, and these are also filed alphabetically according to the names of the

streams. The third section is made up of map drawers, and contains the gauge height-area, gauge height-mean velocity and gauge height-discharge curves, and plotted cross-sections, which are filed alphabetically, according to the names of the streams. The same section contains the maps showing the outlines of the drainage basins, filed numerically according to the number of the sectional sheet. The rating curves for the current meters are also filed in this section numerically, according to the office numbers of the meters. The bottom section of the cabinet consists of letter-size pockets, alphabetically arranged for each gauging station. The tables of gauge heights, discharge measurements, daily gauge height and discharge, monthly discharge, a description of the station, and memos of any changes are filed in these pockets. The different rating tables for each meter are also filed numerically in this section, and another drawer contains the daily and monthly reports of the meterological service.

The copying and filing of the reports of the gauge height observers and the engineers is entrusted to the office recorder. While doing this he carefully examines all records to see that there are no errors, and where there are doubtful or impossible records it is his duty to have the data corrected or ascertain the cause of the unusual condition. He also makes out the pay list for the observers and conducts the correspondence relating to the records.

All computations are checked before being used or published. For this reason, as far as possible, men with some technical education, or students in science, are engaged as helpers. The gaugings are computed by the helper and his work is checked by the engineer. In some instances, where there is a great deal of driving and camping out, the engineer cannot secure a helper who can compute discharges, and in that case he computes the discharges himself, and his computations are checked in the office.

Gaugings of the flow under ice are usually made by using the multiple point method, and vertical velocity curves have to be plotted to determine the mean velocity in the vertical. The computation by this method is long and tedious and cannot be done by the engineer in the field. There are, therefore, a great many computations to be made in the office, and the services of a computer are required.

The results of the discharge measurements are plotted on cross-section paper by one of the assistant engineers as soon as they are received in the office, and thus a very close check is kept on the records, and errors can be detected at once, and in most cases can be rectified. At the same time the records are kept up to date, and demands for provisional estimates can be met at an early date. Important changes in the flow are also detected at once, and instructions are issued without delay to the field men to obtain further gaugings. The methods used in gauging streams will be discussed in a future article.

Several articles describing special applications for searchlights, which have been developed during the war, are contained in a recent issue of *Popular Mechanics*. The first of these describes a method, developed by an American, to locate submerged mines. A powerful enclosed searchlight is mounted under water to one side of the vessel and near the bow. Slightly above the searchlight there is a periscope mirror arrangement, enclosed in a tube coming up to the deck, through which, it is claimed, the observer can see any object illuminated by the searchlight beam at a distance as great as 2,000 feet.

PROPER METHODS OF LAYING WOOD PIPE.

By John H. Curzon, A.M.Can.Soc.C.E.

FROM the earliest days of civilization, when man found it necessary to convey water from one point to another, wood pipe has been used for the purpose. Probably the man who thus converted the great forces in Nature to the use and convenience of man became the first civil engineer. At any rate, his actions in building the first pipe line certainly fulfilled the great definition as laid down by the Institution of Civil Engineers, and which has ever since remained the principal foundation-stone of the great profession of civil engineering.

One would think that wood pipe would have increased in efficiency from the start, but such is not the case. For many years it did increase in quality and efficiency as a water carrier, but when iron pipe became a possibility, the curve of progress in efficiency of wood pipe flattened out considerably. For some time the metallic pipe held sway until market conditions and other reasons again brought wood pipe into use. For the last thirty years the curve of efficiency of use and manufacture of wood pipe has gradually had an upward trend, until to-day it is the equal of any other pipe, under suitable conditions, of course. Wood pipe is not suited

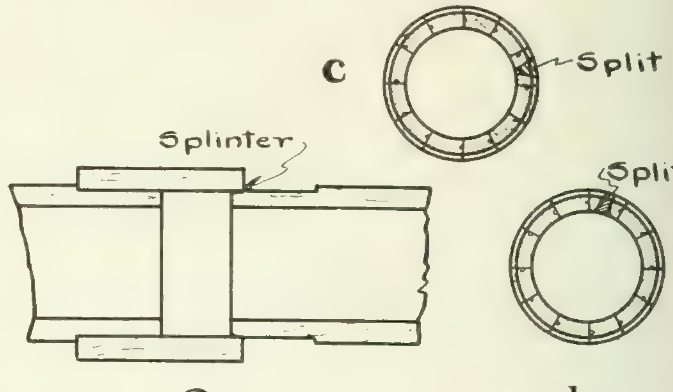

Fig. 1.

to all uses, and will not always be economical in places where iron, concrete or vitrified clay pipe could be used.

Assuming that the pipe has been properly manufactured, and that it is being put to use under favorable conditions, then the method of laying it becomes of prime importance. Wood pipe, that is, the stock sizes, which are manufactured ready to lay, and not only in staves to be bound together, is one of the simplest and easiest forms of pipe to lay. It requires no caulking or the use of any other material in making the joint absolutely watertight.

Pipe which has been well finished and not damaged in transit and has been kept dry can be easily driven by a plug and dolley. If the pipe has been manufactured with ends oversize, and sometimes this is done in order to protect the ends during shipment to the job, then it is only necessary to use a rasp or paring-knife to prepare the ends for driving. Each individual joint should be tried before preparing the ends, as the pipes are very seldom uniform throughout. The wood in one pipe may be dried a little more than the wood in the next pipe, or the cellular texture of two adjoining pipes may be different, necessitating different degree in preparation

of the ends. Axle grease or tallow, when used in moderation, may be smeared on the spigot ends to aid in driving the pipes together. The grease will not reduce the efficiency of the joints, and will help in preventing splinters from turning back, and thus causing leaks.

The inspector on the work must look carefully for split or broomed ends of pipe, as even a small splinter turned back in driving the pipes together will cause leakage. The section of a joint shown in Fig. I. (*a*) illustrates this. Splits may be forced in by driving and form very large leaks. In Fig. 1 (*b*) and (*c*) is shown two forms of splits which are often caused by the pipe being roughly handled in transporting. In case (*b*) the split portion is likely to be forced inward by driving and by the expansion of the wood in the pipe when it becomes damp. Such a leak may not show in a short test, but will develop with use. A leak formed by such a split is likely to run back into the pipe for several feet. The asphalt coating will be blown off if any great pressure is put on the pipe. In case (*c*) the split is not likely to affect the watertightness of the pipe, as when the collar or bell is driven over it, it will force the pieces together and prevent leakage. For small heads such a defect should not cull the pipe, but for heavy pressures it, of course, is not as desirable as solid pipe. Where splits such as these occur it is well to cut off the damaged end of the pipe and re-form the spigot. This is done by clinching a staple over the wire back of the injured part. The wire is then cut and unwrapped from the pipe, leaving the wood ready to be sawn. The end is then pared off and filed to the proper size.

The method of driving the pipes together is by means of a plug and dolley. The plug is a piece of hardwood, about 18 inches long, with iron bands shrunk on each end to prevent splitting and swelling in wet work. The dolley is made of a fir or tamarack railroad tie, about 4 feet long, and should have iron rings shrunk on the battering end to prevent brooming. The apparatus is illustrated in Fig. 2. The dolley is suspended from a wooden horse or frame placed across the ditch. The plug, which is inserted in the pipe to be driven, is battered by the dolley, which is pulled backward and forward by several men. Usually one man stands ahead in the ditch and pulls the dolley back after each blow. One or two men stand on the pipe while battering the plug with the dolley. One man on top regulates the length of the suspending rope or chain.

This method is very effective, and great speed is possible when the pipe-laying gang have been trained to the work. On an 8-foot ditch 1,629 feet of pipe were laid in a day of 10 hours, the gang of eight men being distributed as follows: One foreman; one man part time preparing pipe-ends, filing, greasing, etc., and part time tamping earth around the finished line; two men on surface dropping pipe in the ditch; three men in the ditch driving pipe, and one man clearing out bottom of ditch before the pipe-laying crew. It was necessary for the whole crew to go back to help with the tamping a couple of times. The ditch was in exceptionally good ground, and had been dug by an Austin trenching machine. Averse to this record should be placed another, in which twelve men in 10 hours laid only 61 feet of pipe. This was over ground that had to be hand-dug, as it was yellow clay, and the machine was so heavy that the sides caved in as soon as dug out, necessitating close sheathing. It would have been easier to handle if the machine had not started at all in this kind of ground. A fairer average for wet trench, which had to be partly mucked out and stones removed, is 360 feet laid by five men in 10 hours. The above data are from the records of an 8-inch wood pipe line laid in Southern Saskatchewan by the J. A. Broley Contracting Company for the Canadian Pacific Railway Company.

Before backfilling the pipe should be well surrounded by earth, being well tamped in place. This will prevent the pipe from shifting its alignment, and will to some extent preclude the possibility of stones working their way down to the pipe. Backfilling is usually done with a team and Fresno or buck scraper. A new backfilling machine has been put on the market by the Austin company which should help considerably in the work.

If the pipe is subject to shocks due to valves or gates, or is on a pressure line which is subject to the throb of pumping, great care must be exercised to prevent any stones or rock from coming in contact with the pipe. Stones which touch the pipe are a source of subsequent leakage, caused by them wearing through the wire and allowing the staves to open out. If stones are in the backfill, they must be carefully placed with 2 feet or more of tamped earth between them and the top of the pipe.

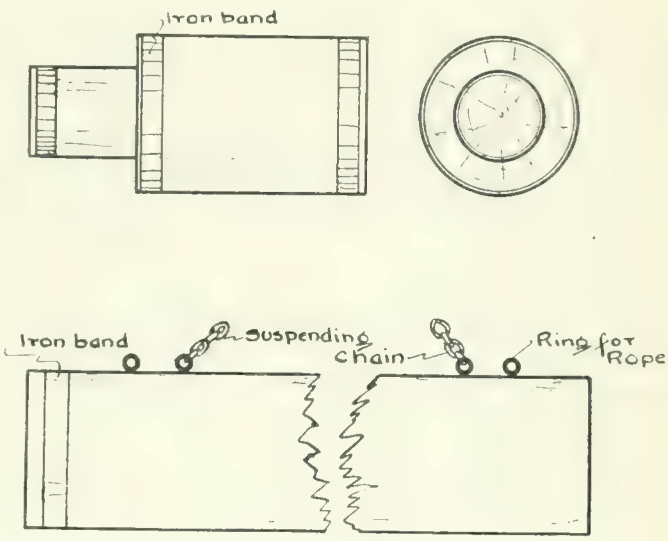

Fig. 2.

Curves may be made with the ordinary pipe by deflecting each pipe about 2 inches. This will not materially reduce the efficiency of the connection. The above applies to sleeve-connected pipe, in which the sockets are deep. For mortise-and-tenon joints probably about one-half this amount is all that can be deflected with safety.

In laying the pipe a small amount of water in the trench is not detrimental to the work, as it would be in metal pipe, the quantity allowable only being limited by the buoyancy of the pipe and the discomfort to the workmen caused by splashing water in driving. Owing to the buoyancy of wood pipe, it is necessary to keep the backfillers close behind the pipe-layers. One contractor at least has had occasion to regret that he did not do this, as a rainstorm filled the low parts of his ditch and lifted the pipe, allowing the tamped material and other washed-in-sand to get below the pipe. This necessitated the removal and replacing of over a thousand feet of pipe.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Wiring Houses for the Electric Light, together with special references to low-voltage battery systems. By Norman H. Schneider. Published by Spon & Chamberlain, New York. Second edition, revised and enlarged. 112 pages, 5 x 7 ins., cloth, illustrated. Price, 55 cents.

A handbook of practical information for those who wish to install their own lighting plants. The book deals with low-voltage systems as the one most suited to household use. For the man who has a hobby for doing things about the house the book should contain some valuable information on wiring.

Oxy-Acetylene Welding and Cutting, Electric and Thermit Welding.—By Harold P. Manly, Chief Engineer the American Bureau of Engineering. Published by Frederick J. Drake & Co., Chicago. 216 pages, 4½ x 7 ins., illustrated. Price cloth, $1.00; leather, $1.50.

The author states in the preface that his object in preparing the book has been to cover not only the several processes of welding, but also those other processes whose methods are so closely allied as to make them a part of the whole subject of joining metal to metal with the aid of heat.

The book commences by describing the various metals, their properties and uses. Then the production and handling of gases and other materials and the use of tools and accessories is taken up. The use of the gases in connection with welding and cutting is then explained, along with some very practical instructions for the proper handling of work of this nature. The instructions are very easily understood and are placed in the order in which they would occur in actual practice. To those who are engaged in this trade the book will be found to be of great practical value. It is of a handy size, well bound, and the information is readily accessible without wading through a mass of unnecessary reading matter.

Dictionary of Altitudes in the Dominion of Canada.—By James White, F.R.S.C., F.R.G.S., Deputy Head and assistant to chairman Commission of Conservation. Published by the Commission. Second edition. 251 pages, 6 x 9 ins., cloth.

The second edition of this work, in which the elevations have been thoroughly checked and brought up to date. The dictionary has also been considerably enlarged. The book is supplementary to "Altitudes in Canada" by the same author, and the information contained therein is more conveniently arranged than that in "Altitudes in Canada." With this arrangement it is only necessary to know the province in which a certain station is located in order to find its elevation. The station names are arranged alphabetically for each province and territory. Latitudes and longitudes of the points are also given for some of the provinces. For a quick reference book of elevations its value is apparent.

Pole and Tower Lines for Electric Power Transmission.—By R. D. Coombs, C.E. Published by McGraw-Hill Book Co. 272 pages, 6 x 9 ins., 162 illustrations and 30 tables, cloth. Price $2.50. Reviewed by J. H. Mackay, Engineer, Toronto Power Co.

It is worthy of remark that, during the last decade, since the advent of long-distance, high-tension transmission of electrical energy, there have been very few worthy publications brought out (other than the proceedings of the A.I.E.E.) that have kept pace with the rapid advancement in this branch of engineering, particularly in connection with the design and construction of the transmission line itself.

Here, in America, existing conditions are such that a continuity of service must be maintained between the source of energy and the market, often hundreds of miles apart, and the thousands of horse-power transmitted necessitate voltages greatly in excess of those of a few years ago, and, in fact, greater than the present-day requirements of the more thickly-populated countries of Middle Europe. This fact, combined with the widely different character of the territory passed through, and the great range of temperature often to be considered along with other climatic conditions, has called forth the best efforts of our engineers in this connection to design and construct transmission lines that will successfully fulfil the requirements of our own continent.

The book by R. D. Coombs, C.E., "Pole and Tower Lines for Electric Power Transmission" (just issued), has been written from the standpoint of American practice, and in a short review of same the following comments are offered:—

The subject matter of the volume, covering some fourteen chapters is suitably arranged under proper headings, the discussions interesting, and the data compiled in a clear, concise and readable manner. As the author states, his object is more to give the reader a clearer perception of the application of the laws of mechanics as applied to the case in hand than to deal with purely electrical problems.

The design of the supporting structures or towers, along with the construction methods and various materials employed in connection with many of the American transmission lines, are described at some length, and the many tables and computations incorporated in these chapters are valuable.

Tables are contained in Chapter 6 which are of interest and value to the engineer, and, in fact, to anyone interested or connected with the transmission of electrical energy these tables, giving all the principal data relative to the higher voltage lines throughout the world. There is a slight error in two places in Table 28a, giving the gauge of the Toronto Power Co.'s copper conductors as 198,000 C.M., which, to be correct, should read 190,000 C.M., but before the next edition of the book goes to press this small error may be corrected.

The chapters devoted to wooden poles, concrete poles, steel poles and towers and special structures are all creditable, giving, as they do, all the most approved methods of present-day construction along these lines. In connection with the use of wooden poles, the various methods of impregnation or preservative treatment are described, the relative values of the pressure, open-tank and brush treatments being discussed.

Foundation work receives due consideration, the chapter devoted to same being replete with illustrations showing the most approved practice in this connection; and again, the chapter on erection and costs, and on general specifications, is creditable.

From an operating standpoint the question of insulators is of vital importance, and the relative values of the suspension and pin-types receives consideration.

During the past year some of the larger American companies have introduced some radical changes in the mechanical design of pin-type insulators for higher voltages, and these, we trust, will eliminate, to some extent, the defects that have developed in the past. However, the practical limit of the pin-type, as at present developed, is in the neighborhood of 85,000 volts, as, beyond this voltage, the leverage, caused by the excessive length of pin required, becomes too great, the small amount of porcelain separating pin and conductor solicits puncture, and the weight and manufacturing cost become excessive; therefore, for transmission lines to be operated above 85,000 volts, the suspension type is as yet the only solution of the insulator problem.

In conclusion, it may be said that Mr. Coombs has covered the field in a manner creditable to any writer, and is to be complimented on the arrangement of his subject matter and the general excellence of the photographs selected with which to illustrate his book.

The Caisson as a New Element in Concrete Dam Construction.—A proposal made in connection with the Columbia River Power Project. By O. G. Aichel. Published by Spon & Chamberlain, New York. 32 pages, 10 x 7 ins, paper, six folding plates. Price, $1.00 net.

An essay describing a proposed scheme of construction of a concrete and steel arch dam on the Columbia River, near The Dalles, Oregon. The proposal presents some novel features, the erection of a caisson in tunnel under the river-bed and its subsequent raising being a new method for carrying out work of this nature. The author has eliminated any preliminary studies as to the reasons for adopting the scheme. The proposed method of construction is given with much detail, the work being divided up into five periods of construction as follows: shaft-sinking and tunnelling; erection of caisson and building of base of dam; excavation of main tunnel chamber; blasting of the roof of the main tunnel chamber; lifting of the caisson and building up of the dam. The essay should be of interest and value to those engaged in the design and construction of large dams.

The Metallography and Heat Treatment of Iron and Steel. By Albert Sauveur, Professor of Metallurgy and Metallography in Harvard University and the Massachusetts Institute of Technology. Published by Sauveur and Boylston, Cambridge, Mass. 504 pages, 7¼ x 10½ ins., 438 illustrations, cloth. Price, $6.00 net. (Reviewed by John B. Temple, B.A.Sc., Toronto Iron Works.)

Three years ago the first edition of this educational treatise appeared, and in order to keep abreast with this fast-growing science the author now offers a revised edition which has been almost entirely re-written and presents much new material.

This book will commend itself possibly more to the student or the teacher than to the metallographist, as each chapter is arranged somewhat after the style of a series of lectures dealing with the subject from the ground up. However, the metallographist or engineer who wishes to brush up his knowledge of the subject will find much valuable information condensed in its pages.

The first three chapters deal entirely with the apparatus and manipulation of same for the modern metallographic laboratory. The next two chapters have as their chief object the explanation of the facts and theories regarding crystallization. The more serious work of the book is continued from this point on.

We would possibly advise the reading of the last three chapters first. These deal with the equilibrium diagram, the phrase rule, and the nomenclature of microscopic constituents. On account of their complexities, these discussions have been left till the last, but on a clear understanding of these chapters (particularly the equilibrium diagram) hinges the whole subject.

A noteworthy feature of the book is the many excellent photomicrographic illustrations setting forth clearly the structures of iron and steel in their many forms.

Altogether, Mr. Sauveur presents an excellent, well-balanced treatise and covers the subject very thoroughly.

Oil Fuel Equipment for Locomotives and Principles of Application. By Alfred H. Gibbings, A.M.Inst. C.E. Published by Constable & Company, Ltd., London. 125 pages, 5½ x 8½ ins., 42 figures and 16 tables, cloth. Price, $2.00.

This book covers the principles of combustion as applied to oil-burning locomotives. The various methods of burning oil fuel by steam jet; compressed air jet, and pressure jet systems are fully described and the advantages and disadvantages of each are taken up. The pressure jet system is enlarged upon in a whole chapter in which several types are described. Burners, fire-boxes and draughts are studied and their effect upon the efficiency of operation is noted. The proper disposition of the apparatus connected with a pressure jet system is shown, and illustrated on a diagram. The author states that the publication is intended chiefly for the use of locomotive superintendents and others who have the control of railway engines using oil as fuel.

The book deals with its subject in a clear and practical manner and is to be recommended to railroad men and

others who are interested in the widely increasing use of oil as a fuel for locomotives.

Proceedings of the American Electric Railway Engineering Association, 1915. Published by the Association, E. B. Burritt, secretary, 8 West 40th Street, New York. 623 pages, 6 x 9 ins., cloth, 106 illustrations.

These proceedings contain the complete report of the thirteenth annual convention of the Association, held in San Francisco last October. The committee reports include a widely diversified list of subjects. Among them are reports on many matters in which the results of investigations carried on as to the proper foundations for car tracks on paved streets are shown. Other reports are on Building and Structures; Lightning Protection; Power Distribution; Block Signals; Equipment; Power Generation, and Heavy Electric Traction. The last-named report is largely given over to a study of modern electric locomotives, and with it there are given 37 views and plans of American and foreign electric engines.

Dams and Weirs. By W. G. Bligh, Inspecting Engineer of Irrigation Works, Department of Interior, Canada. Published by American Technical Society, Chicago. 206 pages, 122 figures, 5½ x 8½ ins., cloth. Price, $1.50. (Reviewed by Thos. H. Hogg, Hydraulic Engineer, Ontario Hydro-Electric Commission.

This little volume comprises an analytical and practical treatment of gravity dams and weirs, arch and buttress dams, submerged weirs, and barrages. Each different type of profile is given a careful analysis followed by typical examples which are studied in relation to the theory, showing the good and bad points of the design.

Perhaps one of the most valuable features of the book is the interesting comments on actual work, based on what the author's experience has shown to him to be practical and based on good practice.

This brief but authoritative treatise should be well received by those of the profession interested in the design of dams and weirs.

PUBLICATIONS RECEIVED.

Railway Statistics.—Returns of the Canadian Railway Companies for 1915.

Abstracts of Current Decisions on Mines and Mining.—Bulletin No. 113 of the United States Bureau of Mines.

Hydro-Electric Power Commission of Ontario.—Eighth annual report for year 1915. 466 pages, illustrated.

Report of the Minister of Public Works for the Province of Ontario, 1915. Illustrated report of work done during the year. 186 pages.

Manufacture of Gasoline and Benzine-Toluene from Petroleum and other Hydrocarbons.—Bulletin No. 114 of the United States Bureau of Mines.

Methods for the Determination of the Physical Properties of Road-Building Rock.—Bulletin No. 347 of the United States Department of Agriculture.

Texada Island, B.C.—Memoir No. 58, by R. G. McConnell, of the Geological Survey of Canada. Published by the Department of Mines. 112 pages, illustrated.

Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials.—Bulletin No. 348 of the United States Bureau of Agriculture.

The Electrical Resistances and Temperature Coefficients of Nickel-Copper-Chromium Alloys.—By Frederick M. Sebort. Published by the Rensselaer Polytechnic Institute.

Report of the Minister of Lands, Forests and Mines.—The report of operations of the Department of Lands, Forests and Mines of the Province of Ontario for 1915. 90 pages, illustrated.

Geology of Cranbrook Map-Area, British Columbia.—Memoir No. 76, by Stuart J. Schofield, of the Geological Survey of Canada. Published by the Department of Mines. 246 pages, illustrated.

Contributions to Canadian Biology, being a report of studies carried on at the biological stations of Canada during 1914-15. Supplement to the fifth annual report of the Department of Naval Service, Fisheries Branch. 172 pages, illustrated.

The Artesian Wells of Montreal.—Memoir No. 72, by C. L. Cumming, of the Geological Survey of Canada. A report of deep borings made and other investigations of the subterranean waters in the vicinity of Montreal. Published by the Department of Mines. 154 pages, illustrated.

CATALOGUES RECEIVED.

Permanent Concrete Roads.—A pamphlet describing and illustrating the various devices used for concrete paving. Published by the Trussed Concrete Steel Company of Canada.

The Nordberg High Compression Two-Cycle Oil Engine.—Bulletin describing the engine and its operation. Issued by the Nordberg Manufacturing Co., of Milwaukee, Wis., U.S.A.

Imperial Asphalt.—A 24-page and cover illustrated booklet, distributed free by the Imperial Oil Co., Limited, Toronto. It discusses various types of asphaltic roadways and streets, and gives directions for construction. A plan of the company's new refinery at Montreal and 15 other illustrations are included. Printed in four colors.

Concrete Roads.—A 38-page, illustrated booklet, distributed free by The Canada Cement Co., 782 Herald Building, Montreal. It discusses, in a most interesting manner, the need for good roads and the utility of concrete as a road material. There are thirty-seven illustrations, and the general appearance of the booklet is attractive. Specifications and construction pointers are included. A list of concrete lanes, streets and roads in Canada totals 2,259,081 sq. yds., of which 682,414 sq. yds. were laid in 1915, an increase of about 24 per cent. over 1914.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a meeting of the Society held on April 13th an informal talk on the difficulties experienced in building the Panama Canal was given by John Murphy, chairman of the Ottawa Branch. The talk was illustrated with slides.

Col. Snyder drew diagrams explaining in an interesting manner the preparation of military maps.

Editorial

CALGARY ENGINEERS SETTLE DISPUTE.

Certain action recently taken by the Calgary Branch of the Canadian Society of Civil Engineers, and approved of by the Council of the Society, deserves special publicity as illustrating one of the many ways in which such a society serves the interests of the engineering profession as well as of the public in general.

G. W. Craig, city engineer of Calgary, Alta., had been seriously criticized in regard to a reinforced concrete arch bridge over the Bow River. The city council had ordered the Board of Commissioners to investigate the charges, and the citizens of Calgary believed, as a result of the discussion, that the safety of the bridge, which was under construction, was endangered. The controversy was very technical, and the public could not judge of its merits.

At that stage the Calgary Branch held a general meeting and passed a resolution offering the gratuitous services of the branch in determining the technical questions involved. The city accepted the offer, and the branch named a committee of three of its prominent members, who were independent of all civic politics. The report of the committee, stating that they could "find no reason for the charges, and are unable to understand why they should ever have been made," was adopted by the city council, and the city engineer was thus fully exonerated.

"Mr. Craig," says the committee, "showed a very complete knowledge of the general questions of the design and of the history of the particular questions in controversy."

Mr. Greene, the city's bridge engineer, and Mr. Field, the city chemist, were examined. The committee then visited the work, where various employees were questioned, and a visit was paid to the city laboratory, where samples of steel were tested, and the equipment at the laboratory and methods of tests were noted.

The charges that had been made in connection with the bridge were as follows:—

(1) The use of unsuitable steel in a portion of the structure, and extravagance in cost of testing the same.

(2) Neglect or carelessness in not carrying the foundations of the north retaining wall or abutment to rock.

(3) Failure on the part of the engineering department to submit the design to a consulting engineer for endorsement, "it having always been understood that such a course would be followed."

(4) Purchase of unsuitable cable at a higher price than suitable cable could have been bought for.

In regard to the testing of the steel, the committee "cannot see how any private firm could make the necessary tests and inspection any cheaper than the city has done in this case." The committee's report goes very fully into the character of the material used in the bridge and deals with the questions of physical tests, specifications for steel, re-rolled steel, process of manufacture, significance of tests, and so on. In regard to the use of re-rolled steel, the report says:—

"It has been used as reinforcement in the construction of the retaining wall which forms a part of the north abutment. It has also been used, or is contemplated, as dowels to furnish a bond between successive pourings of concrete in the river piers and springings. It was also used, or contemplated, in the curtain walls of the main piers and pylons of the river arches, and as carriers or spacing rods in various other parts of the work. With the exception of the retaining walls, the function of the steel is arbitrary, and the material is subject to no definite stresses. In the pylons, the curtain walls are a mere architectural effect and have no structural functions. The steel is used merely to prevent unsightly cracks due to temperature and shrinkage stresses, and its section is in most cases far in excess of possible requirements."

In regard to carrying the foundations of the north retaining wall or abutment to rock, the committee "are of the opinion that the wall is reasonably safe against failure, and that the additional expenditure necessary to carry this wall to rock would not be justified by the returns."

The stresses in the retaining walls were checked, and the possibility of failure investigated. The calculated loads are moderate, and the methods of calculation adopted are conservative. The committee are of the opinion that failure from any of the causes mentioned in the charges is a very remote possibility.

As to the submission of the design to a consulting engineer, the committee found that there was no common understanding to that effect. "As to the advisability of such a course," says the report, "the decision must be made by the parties who pay for the work. In general, when a proposed structure departs widely from well-established precedents, or the designer has not had the necessary progressive experience in the design of structures of such magnitude or importance, it is usually considered wise to employ an outside opinion to check over the design, or to pass on some particular feature of the construction. When the structure is well within precedent as well as the experience of its designer, the expense of a consulting opinion may not be justified. It might be remarked at this point that no consulting engineer whose opinion would carry any weight, would guarantee the safety of a structure any more than a counsel would guarantee the result of a suit at law, or a surgeon the result of a major operation. The decision as to the employment of a consulting engineer does not and should not rest on the designing or executive engineer. It is his duty in certain cases to suggest an outside opinion and in others to point out to his employers or clients, on request, the facts which may or may not justify the expense of such an opinion, but it is seldom his duty to insist on it."

The responsibility for the purchase of the cable was assumed by the city commissioners, and the opinion of the Calgary Branch on this matter was not required.

The Canadian Engineer has had the opportunity of perusing the voluminous details of the case, as brought out by the committee, and it can be readily seen that they undoubtedly represent a great deal of painstaking work. The Calgary Branch are to be congratulated upon their initiative. The unselfishness of their action is proven by the fact that Mr. Craig is not a member of the Canadian Society of Civil Engineers.

PERSONAL.

C. L. GIBBS, architect, of Edmonton, has enlisted with the University of Alberta Company.

A. H. BROWN has resigned as manager of the Hudson Bay Mines, Limited, Porcupine, Ont.

JOHN H. KILMER, A.M.Can.Soc.C.E., has been appointed city engineer and inspector of waterworks construction at Port Moody, B.C.

LUCIUS C. ALLEN, consulting engineer, Belleville, Ont., announces the removal of his office to the new Bank of Commerce Building in that city.

CHARLES P. LIGHT, who for some years has been field secretary of the American Highway Association, has resigned to enter the business of life insurance.

GEO. D. MACKIE, city engineer of Moose Jaw, Sask., has been appointed a member of the Royal Commission to investigate the Saskatchewan Highways Department.

W. D. MACKAY, NORMAN E. LYCHE, M. H. RAMSAY and FRANCIS B. MONTEITH have qualified for commissions as B.C. Land Surveyors at the April examinations.

H. K. WICKSTEED, M.Can.Soc.C.E., chief engineer of surveys, Mackenzie, Mann & Company, Limited, has been in Venezuela in connection with a coal mining and railway proposition.

W. J. RENIX, district master mechanic at Revelstoke, B.C., and who was formerly shop foreman of the C.P.R. at Moose Jaw, Sask., has been promoted to the position of divisional master mechanic at Moose Jaw.

HENRY HARVIE has resigned from his position as designing engineer for the Rochester Railroad & Light Company to become chief draftsman for the hydraulic department of the Hydro-Electric Power Commission of Ontario, with headquarters at Toronto.

ROBERT McKILLOP, who was appointed superintendent of District No. 2, Atlantic Division at Woodstock, N.B., has been in the service of the C.P.R. since 1905. Mr. McKillop held the post of assistant engineer and chief draftsman of the engineering department at Montreal until February, 1915, when he was appointed division engineer of the eastern division.

Lieut.-Col. J. A. HESKETH, M.Can.Soc.C.E., formerly Assistant engineer, C.P.R., Winnipeg, and District Intelligence Officer and Officer Commanding the Corps of Guides, with headquarters at Winnipeg, who went overseas with the Canadian Expeditionary Force shortly after war broke out, and who is now in Strathcona's Horse, was married in England, March 14, while on leave from the front, to the widow of J. E. Schwitzer, who, when he died in 1911, was chief engineer, C.P.R., Montreal.

Major A. G. L. McNAUGHTON, of Montreal, has been appointed to a command, according to a London cable. Major McNaughton, who was seriously wounded at Ypres, was in practice as an electrical engineer in Montreal before joining the overseas forces. He graduated from McGill University, where he was for some time a demonstrator in the electrical course. At the battle of Langemarck, despite a serious wound in the arm, he stayed with his battery for twelve hours and directed its operations. He had two orderlies hold his maps in front of him, and he kept two telephones going in despatching orders.

OBITUARY.

SIR COLIN CAMPBELL SCOTT-MONCRIEFF, well known as an authority on irrigation, died in London, England, April 6, at the age of 80. He was the creator of the present system of irrigation in British India, where the canals aggregate, in extent, the circumference of the globe, and he also inaugurated a similar system in Egypt. Since these works, which took almost half a century to complete, he has been consulted in irrigation projects by the Turkish, German, and Russian governments, and was largely responsible for the idea carried out by Russia in the river regulation and canal construction of its transcaspian and central Asian possessions.

SCHOOL OF MINING BECOMES A FACULTY OF QUEEN'S UNIVERSITY.

The School of Mining at Kingston, Ont., has been amalgamated with Queen's University and will be conducted as a regular faculty of the university, under the direction of the trustees. At the final meeting of the shareholders and board of governors of the school some of the members were elected trustees of the university.

COAST TO COAST

Ottawa, Ont.—J. D. McArthur, promoter and builder of the Edmonton, Dunvegan and Peace River Railway, is in the capital urging on the government that the usual federal subsidy of $6,400 per mile be granted his enterprise. Mr. McArthur pointed out that the road was necessary to the development of the country and the cost had been greater owing to the number of bridges required.

Toronto, Ont.—The Ontario Government plans to devote several million dollars to the development of New Ontario. Intimation to this effect was made in the Legislature by Hon. Edward Ferguson, Minister of Land, Forests and Mines. The government expects to make arrangements whereby it will loan settlers money for development purposes.

Edmonton, Alta.—An experimental sewage disposal plant which will treat part of the city's sewage by the activated sludge system has been completed at a cost of $50,000.

St. John, N.B.—At a meeting of the Board of Trade a strong vote in favor of the Valley Railroad entering the city by the original east side route was recorded.

Montreal, P.Q.—The Montreal and Southern Counties Railway has been completed to the town of Granby. Traffic will open on April 29.

Quebec, Que.—The new C.P.R. Union Station at the Palais is nearly completed, and it is expected that the various freight, ticket and steamship offices of the company will be installed in the new quarters early in May.

Ottawa, Ont.—The chief provision of the bill recently introduced to amend the Railway Act is one giving to the railway board the power to fix the general location of a railway line as well as the right to say whether or not it is in the public interest that it should be constructed.

Volume 30. Toronto, May 4, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

THE ROLLING AND FLOATING STEEL CAISSONS OF THE LEVIS DRY DOCK AT LAUZON, P.Q.*

PART I.

A DETAILED DESCRIPTION OF THE DESIGN, FABRICATION AND ERECTION OF THE ROLLING CAISSON.

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SEVERAL features in connection with the new government dry dock at Levis, P.Q., are very interesting, presenting as they do some rather unique ideas relative to marine work. In this paper, which has been read before the Canadian Society of Civil Engineers, it is the intention to describe only the caissons or gates, although it will be difficult not to stray from this object in attempting to make certain parts the clearer.

The problem which presents itself at the mouth of a graving dock is familiar to the engineering profession. Whatever device is used to close the entrance, must be capable of being swung in or out expeditiously, be able to withstand the hydrostatic load when the berth is unwatered, and also allow the sea water to enter through it when the berth is filling. By this means the dry dock is very quickly filled and a great deal of time is saved. The problem is seen at once to be very similar to that occurring at a canal lock, and it is owing to this similarity that so many of the early graving docks and even some later examples were equipped with mitred gates. There are, however, certain disadvantages connected with the use of mitred gates, such as the length of wall absorbed in housing them when the berth is open, and the absence of a communicating bridge for wheeled traffic when the berth is closed. The use of a rolling caisson, on the other hand, involves neither of these disadvantages, for it is housed in a recess lying transversely to the berth and a communicating passageway is always provided along the top as its width easily admits the economical construction of a folding bridge of some type.

The cost of either type of caisson will usually exceed that of a pair of mitred gates, but is, on the other hand, less than a pair of gates plus a small swing bridge.

The relative suitability of these various schemes to close dock entrances has been summed up by Mr. W. G. Wales in Proc. Inst. C.E., Vol. cxxii., as follows:—

"In conclusion, ship-caissons are adapted for dry docks, and for locks and entrances in sheltered and non-tidal positions; sliding caissons for locks and entrances in tidal and sheltered positions; and dock gates for entrances in exposed positions and for commercial docks."

The layout of the new dry dock is shown in Fig. 1. The main dimensions of the berth are: Length, 1,150 feet; width at top, 144 feet; clearance width at rolling caisson sills, 120 feet; depth of water over sills at mean water level, 25 feet; at extreme high-water spring tides, 50 feet.

At about mid-point of the berth will be noted the bearing sills lettered "C." These are the sills for the floating caisson and are to be used when it is desired to dock vessels less than 650 feet long. Owing to this arrangement it is not necessary to unwater the whole dock for small vessels. Near the outer extremity are seen the sills for the rolling caisson and its recess chamber, while still further out may be seen a pair of bearing sills lettered "A." These are duplicates of those at "C," being moulded to exactly fit the floating caisson. Hence the floating caisson may be used to close either half or the whole of the berth. In the latter capacity it may serve, too, as an emergency gate during a breakdown of the rolling caisson or any part of the interior of the dock, allowing the berth to remain unwatered during all repairs. Consequently, by reason of this layout, two caissons—one rolling and one floating—are able to close one-half or the whole of the berth, as desired, and also supply an emergency gate when necessary. This is a distinctly economical arrangement.

The large dimensions of these caissons are a little difficult to realize inasmuch as the gates are among the largest of their kind in the world. The floating caisson is larger than that at the new Ferrol Yard, Spain, and also longer than the one for the Panama Canal, though not quite so deep. Hence, with a dock length of 1,150 feet and a width of 120 feet there is no danger but that the largest boats that are even contemplated at present, may be berthed with ease at the new Levis graving dock.

In designing the rolling caisson it was necessary to take into consideration the severe climatic conditions to which it would be subjected. The caisson itself consists of a fabricated steel gate 123 feet long, 19 feet 3 inches broad and 46 feet deep. All elevations of this gate are rectangular, and all horizontal sections are trapezoids and similar in outline. The hydrostatic loads are carried to the vertical ends by means of two trusses and one plate girder, and a small proportion to the bottom sill by the skin stiffeners running between the lower truss and the bottom. It is important to grasp at the outset that the water loads are taken first by skin plates to stiffeners or ribs, and thence to two horizontal trusses and a girder;

*Extract of a paper read before a meeting of the Mechanical Section of the Canadian Society of Civil Engineers at Montreal, March 30th, 1916.

and it is these latter that are carrying the real loads of the caisson.

The girder serves to divide the interior into two water-tight compartments, the upper one to be described as the tidal chamber and the lower one to be known as the ballast chamber. This division is placed at a height of 23 feet 6 inches above the bottom of the caisson, and marks the approximate load water line of the gate. Consequently, under normal conditions the large weight on the rollers is greatly relieved by the buoyancy, and the power necessary for rolling the gate is thus materially reduced. As the tide rises above this 23-foot line, it is allowed free access to the tidal chamber, and in this way the complete flotation of the gate is prevented by the automatic introduction of the requisite amount of water ballast. The foregoing is the operation during the summer. In the winter no water is allowed in the tidal chamber, but the ballast chamber is completely flooded and the enclosed water, heated by steam, serves to counteract the buoyancy of the caisson.

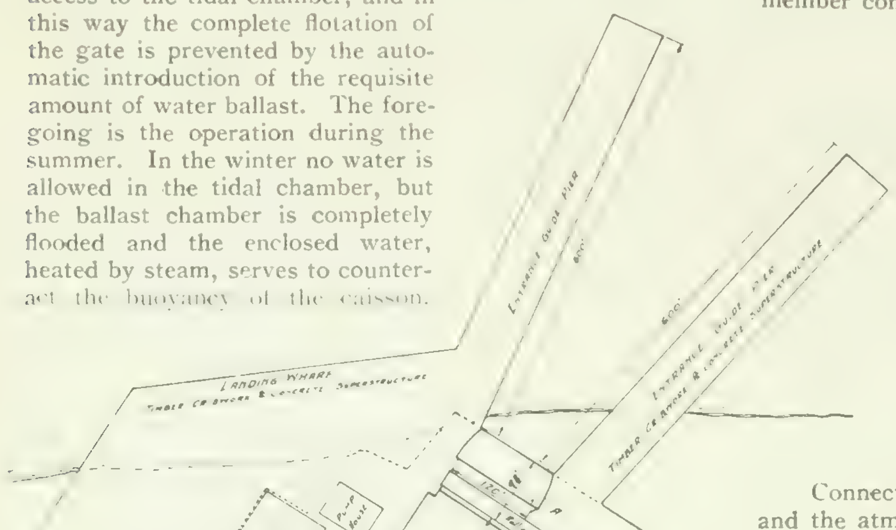


Fig. 1.—Layout of Dry Dock.

The gate is operated by means of flexible cables fastened to each end of a large yoke attached to the inner end of the caisson, which during its longitudinal movement travels on two lines of steel rollers set in the floor of the berth at about 8-foot centres. These rollers bear upon two steel rails on the bottom of the gate, each rail being 6-inch x 9-inch sections of solid medium hard steel, in lengths of about 15 feet. The seal is accomplished by the hydrostatic pressure forcing the caisson against the sills, the actual bearing pieces being 7-inch x 18-inch white oak strips on vertical edges, and 7-inch x 12-inch white oak strips on the horizontal or bottom line.

The skin plates are ¾ inch on the bottom and sides to the height of about two-thirds of the caisson, when ½-inch plate was used. All horizontal seams are single lap joints, all vertical seams are butt joints (D.R.). The vertical skin plates are stiffened by short I-beams and angles placed at 2-foot 10-inch centres, running between bottom and truss A, truss A and girder, girder and truss B, and truss B and top.

The vertical sway bracing is placed between the trusses and the girder, and between truss A and the bottom at every panel point (17-foot centres) except at the top where it is placed at 8-foot 6-inch centres. Each member consists of two 6-inch x 4-inch x ½-inch angles with gussets between for connection to the main material.

The horizontal lateral bracing is placed at the top of the caisson only, at the level of the operating sidewalk. It is designed to provide rigidity against any racking effect that might result from one corner coming into violent contact with the sill.

At the top of the caisson is a folding bridge designed to carry traffic between the two sides of the berth when the caisson is in place, but so arranged that when the caisson is in its recess the bridge is completely folded underneath the roof of the chamber. The operation of this bridge is automatic.

Connection at all times between the ballast chamber and the atmosphere is maintained by means of two oval manholes, each large enough to permit one of the main 42-inch valves being lifted through it to the outside air. Each of them is provided with a ladder inside and thus affords access for inspection, etc.

Running from face to face of caisson are six 42-inch diameter filling culverts controlled by 42-inch gate valves whose stems are taken up to the operating level and there actuated mechanically by a horizontal countershaft, motor driven. There are, also, hand-operated valves for filling and draining the tidal chamber, ballast chamber, etc.

The rolling caisson was designed primarily by Eugene Lafleur, chief engineer of the Department of Public Works. The design proposed, however, was only tentative and the tenderers were given the privilege to submit their own designs. The successful bidders were Messrs. M. P. and J. T. Davis, who turned the work over to the Dominion Bridge Company. A unit stress of 12,000 lbs. per square inch was adopted for the structural steel work. This low stress was in order to take care of any uncertainties as to loading or unavoidable eccentricities.

The loading of the whole gate was assumed, of course, triangular with a unit pressure on the bottom of 2,840 lbs. per square foot, corresponding to a head of 45 feet 6 inches of water. The centres of truss A, the girder and truss B were fixed as 12 feet 6 inches, 11 feet, 10 feet and 12 feet, and on reference to Fig. 2 these are seen. The water pressure of each main division was assumed to act through its own C. of G. and the position of this point determined the proportion that was distributed to each truss or girder. The only point about which any interest might centre is the loading of truss B. It would clearly take its due proportion of W-3 and, owing to the absence of any support at the top of the gate, all of W-4. In addition to these quantities, however, there is an overturning effect due to W-4 that must be resisted. The location of W-4 is 4 feet above truss B; hence, bending moment is $4{,}500 \times 4 = 18{,}000$ lbs. per lineal foot. If

this moment be taken up entirely between truss B and the girder (and this is the assumption that places the heaviest load on B), the extra load on the truss is 18,000 ÷ 10 = 1,800 lbs. per lineal foot. The direct load described above

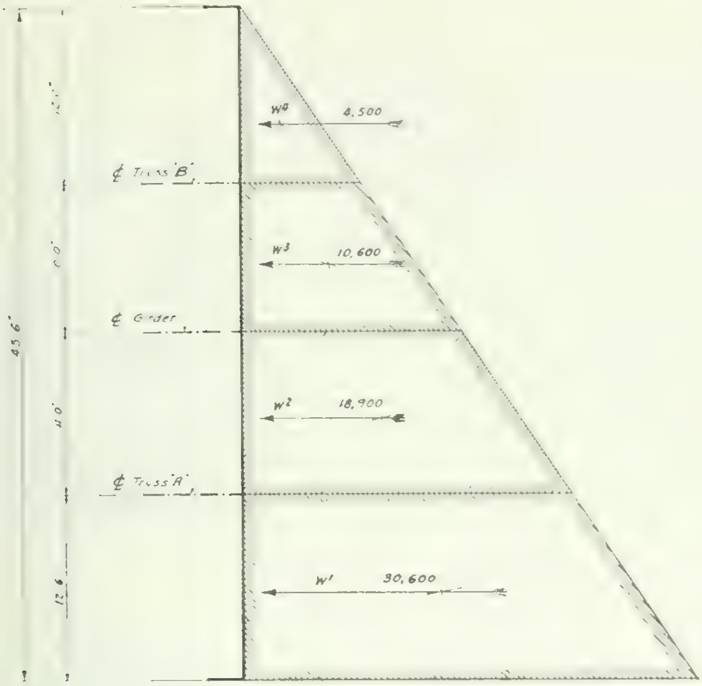


Fig. 2.—Hydrostatic Loading Against Rolling Caisson.

is 9,280 lbs. per lineal foot. Therefore, total load on truss is 11,080 lbs. per lineal foot.

The load on truss A is 24,600 lbs. per lineal foot. As mentioned previously, the unit stress specified was 12,000 lbs. per square inch, and this was interpreted by all parties to mean 12,000 lbs. per square inch tension and the same for compression, unless the Dominion Government Specifications '08 formulae would give less when reduced for $\frac{l}{r}$ ratio.

In summer, the compression chord of truss A would carry the water load between panel points and in winter the tension chord would do the same with, of course, a much smaller head. Owing to the full splicing of the chords the maximum bending moment assumed in them, due to flexure, was $1/10\ w\ l^2$. Preliminary calculations were made on two or three sections of both the compression and tension chords, and average values for extreme flexural fibre stress were assumed in order to fix the exact sections. The average amount deducted from the compression chord, including end post, was 3,200 lbs. per square inch. The $\frac{l}{r}$ ratio for all these sections was so small that no reduction of the 12,000 lbs. became necessary.

In the design of truss A very little need be mentioned except the large sizes of the members and gussets. The chords of this truss are the largest simple truss chords that have ever been built by the Dominion Bridge Company—attention being called to the fact that the gross area of the tension chord in truss A is 342 square inches. The magnitude of this may be realized when one recalls the fact that the cross-sectional area of the centre chord of one of the big Lachine trusses is 302 square inches and that of the lower chord of the St. John arch is 347.5 square inches. In the detailing, every precaution was taken to see that the rivets were capable of developing in each group the requisite amount of stress. The value assumed for rivets stressed in two directions simultaneously was adjusted accordingly.

The horizontal load on the girder is 14,600 lbs. per lineal foot and nothing has been taken from this figure to allow for the negative loading induced in it by the overturning effect of the upper water. The girder is stiffened underneath by 24-inch @ 80 lbs. I's in order to carry the load of tidal chamber when full of water. The cover plates are run far enough beyond their theoretical length to take up their value.

Owing to the magnitude of the loads and to the difficulty of developing the full stress in those portions of the cover plates and skin plates that act as flanges, it became essential to use 1-inch diameter rivets in all main connections of truss A and the girder.

The load on the upper truss B, as mentioned before, equals 11,080 lbs. per lineal foot, and in this truss no difficulty was experienced with the capacity of the rivets, hence ⅞-inch diameter rivets were employed. As in truss A, the working stresses used in the main chords and end post were reduced for flexure by the following amounts: Compression chords, 3,400 lbs. per square inch; end post, 3,000 lbs. per square inch; tension chord, 3,100 lbs. per square inch.

The distribution of the loads bearing on the vertical sides became at once not only very important but also one of the most difficult problems met in the design of the whole gate. The reactions were: Truss A, 1,512,000 lbs; girder, 900,000 lbs.; truss B, 680,000 lbs. The reaction of truss A, if spread over a length of 11.75 feet (½ of 11 + ½ of 12.5 = 11.75 feet its own proportion) and a width of 18 inches would give an average concentration of about

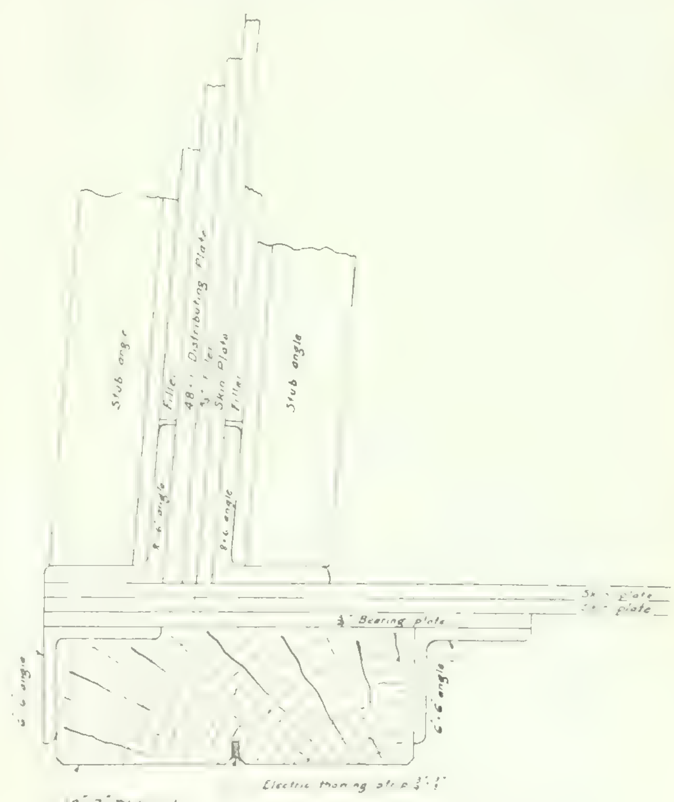


Fig. 3.—Bearing Corner of Rolling Caisson.

86,000 lbs. per square foot—600 lbs. per square inch—which is even then very large for sill pressures. It was felt that, though the width of the caisson was fairly good (19 feet) the end itself would, owing to its construction, be hardly stiff enough to really distribute the highly con-

centrated load of truss A. Various studies were made to attain some thoroughly practical arrangement by which the load could be spread. After careful consideration being given to several schemes, among which may be mentioned a series of radiating struts from the outer extremity of the end post, it was decided to place along the whole bearing surface a 48-inch x 1-inch continuous distributing plate whose edge would be faced to bear on the filler or skin plate lying behind the 18-inch x ¾-inch bed plate between the caisson and its seal-strip angles. This plate was reinforced at varying centres on the outside by pairs of stub angles 5 inches x 3½ inches x ¾ inch, about 4 feet long. On the inside, similar stub angles were placed at frequent intervals. The object of this whole construction was to insure, if possible, that the load, undoubtedly having a tendency to enter the skin plate, would in turn be taken from these skin plates to the long reinforcing plate because of the greater stiffness of the latter due to its continuity. This quality in the reinforcing plate would then, of course, assure the distribution of the load to the oak and thence to the sills.

It was felt that the question of the freezing of the caisson to the sills might seriously interfere with

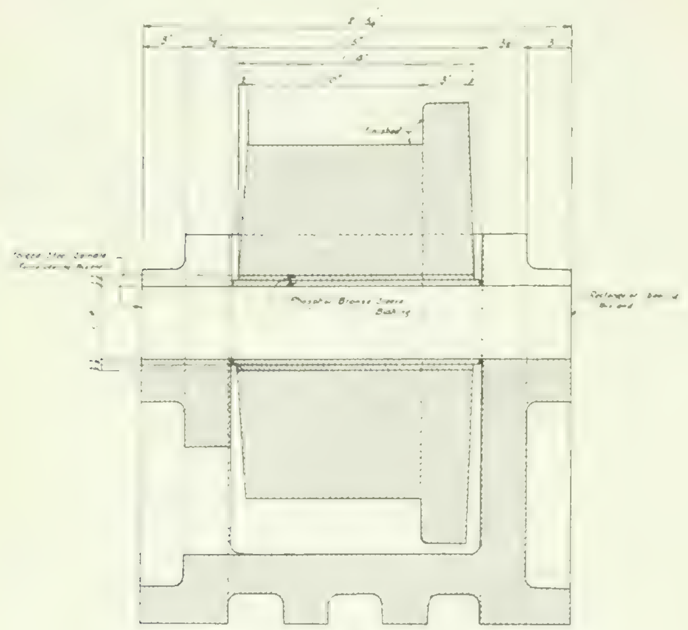


Fig. 4.—Cross-section of Roller.

the satisfactory operation by preventing the hauling mechanism starting the gate after a prolonged contact between it and the sills had been made. This might either overload the hauling devices or else necessitate the installation of heavier units than should be needed, consequently an electric thawing strip has been designed which will run completely around the oak-bearing pieces.

In Fig. 3 will be seen a cross-section of the whole bearing corner. In it can be noted the 48-inch x 1-inch distributing plate, the 18-inch x ¾-inch bed plate, the stub angles, the oak-bearing piece and the thawing strip.

In addition to taking precautions against freezing the caisson to its masonry bearing, it was decided to instal a mechanical device by which the caisson could be moved away laterally from contact with the sills before starting to roll it inwards. By this means no heavy frictional load due to the intimate nature of the contact between caisson and walls would be thrown on the hauling mechanism. In addition, this device could be used to push the caisson against the sills preparatory to its being used as a stop gate. This would prevent the violent jar that would inevitably result were the gradually increasing hydrostatic pressure allowed to finally and suddenly overcome the static friction between the gate and its rollers. Hence a toggle arrangement was designed capable of performing the two above-mentioned duties.

On the berth side of the gate the space between the main bridge longitudinals and the side is filled with 5/16 inch checkered plate. This runs the whole length of the caisson, and constitutes the operating platform or deck. The motor, with its control and rheostats, etc., in a watertight box, all the floor-stands and all hand-wheels for valves, etc., are brought up to this deck and operated therefrom. With this arrangement it is never necessary for a man, for operating purposes, to climb from the bridge to the open parts of the caisson where a slip would probably result in a fatal fall. Thus the safety of the operators during the handling of the caisson has been provided for.

The manholes are two in number. At the lower end they terminate at the girder, and at the upper end, in a watertight hatch about 2 feet 6 inches below the bottom of the wooden bridge. Each manhole affords access, even when the caisson is in service, to the ballast chamber without unwatering the tidal chamber. They are also large enough to permit the big valves being taken up for repairs.

The bridge deck, of wood, is 8 feet 6 inches wide and is carried by two 10-inch @ 35 lbs. I-beam stringers resting in small supporting castings through which run the floor beams of round cold-rolled steel shafting 2¾ inches in diameter. These floor beams lead into the bridge posts, which are flats with forged eye heads at points of floor beam attachment and also at their lower extremities where they are fastened to longitudinal supporting stringers of 10-inch @ 20 lbs. ship channels with flanges turned inwards. This fastening is such that the post may swing in vertical arcs through an angle of about 80 degrees. The upper extremities of these posts are fastened by pivoted connections to fence railings of 3-inch x ⅜-inch flats. Thus the whole system may, owing to absence of stiffening bracing, swing downwards until it lies completely under the top or clearance line of caisson. When in this position the caisson may roll into its recess with no post above the recess cover. In order that the bridge shall not be free to fold by gravity only, counterweights are supplied in three sets of bridge posts which are then extended below the ship channels to receive the counterweight box. The extensions are accomplished by means of special posts of 12-inch @ 25 lbs. channels.

As the only occasions when the bridge must be folded occur when it is in its recess, it was decided to make this folding automatic.

The skin plates are designed to figure as small strips of unit width acting as continuous beams over a large number of supports $\frac{1}{12} \cdot w l^2$ being the moment formula used. No attempt was made to combine bending stresses in skin plates in the vicinity of the trusses with the main chord stresses induced in them in virtue of certain portions being taken as chord material.

The draw bar pull is exerted on the end of the caisson by means of a large bracket bolted with twelve 1¼-inch diameter bolts, and knee-braced below. These bolts are 3 feet ½ inch long and, passing through the skin plates, engage a steel anchorage that thoroughly distributes the load. By means of a 15-inch horizontal channel a certain proportion of it is conveyed to a number of the small vertical channels, but the major portion of the draw bar

pull is taken by four 8-inch x 6-inch angles to the top sides of the caisson.

The bottom of the caisson is stiffened by 24-inch @ 80 lbs. I's placed at 2-foot 10-inch centres and has also about 6 feet of solid concrete ballast which, of course, aids in distributing the loads delivered by the 6-inch x 9-inch steel rails.

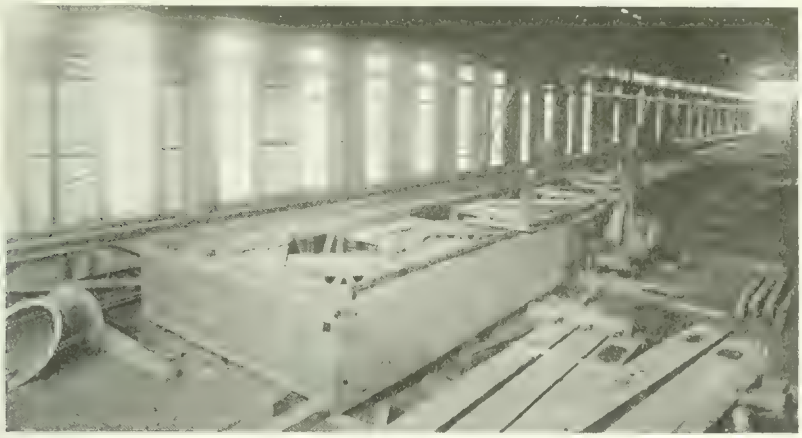


Fig. 5.—Truss "A" Assembled in Shops.

The rollers for this caisson are of solid steel 2 feet in diameter with a flange 3 inches x 3 inches, and a face width of 1 foot. The thickness along the bearing is 16 inches. Fitted on the inside of the rollers is a phosphor bronze bushing 16 inches long and 3/8 inch thick. This bears on a phosphor bronze sleeve 16¾ inches long and also 3/8 inch thick. This sleeve in turn fits over and bears upon the forged steel spindle 5 inches in diameter. One end of this spindle is forged square to prevent it turning in its bearing. The frame for the bearings (one frame per roller) is cast iron, of heavy design with its outer surface deeply indented to make an intimate bond with the concrete. These details are exhibited in Fig. 4, which shows a cross-section of one roller and frame.

The fabrication of this caisson proceeded along the usual lines for first-class bridge work. Complete detail drawings were prepared and wooden templates made.

As will be remembered, truss A and the girder were designed for 1 inch diameter rivets and truss B for 7/8 inch diameter rivets. In order to keep all punching the same it was decided to punch everything 15/16 inch. This would be, of course, sub-punching for truss A and the girder, and full size for truss B. In the former cases the holes would be reamed to 1 1/16 inches for the 1 inch rivets.

In order to be sure of accurate fitting, truss A with its skin plates, and parts of the girder were assembled in the yard and the reaming was then done. Fig. 5 shows the truss A being reamed. A good idea of the weight and size of the members may be obtained by comparing the depth of the chord with the man beside the reamer. The magnitude of the heavy gussets may also be noticed.

The hydraulic features consist of six main culverts used to flood the berth; four valves to let sea water into tidal chamber; two valves to let sea water into ballast chamber; valves to drain the superfluous water off the tidal and ballast chambers. The six main culverts are of 42-inch diameter steel lap riveted section, terminating in forged flanged ends riveted to the sides of the caisson and bolted to the flange of the main gate valves, whose vertical outer lines are located 3 feet 10¾ inches from the berth side of the caisson.

The inlets for sea water in the tidal and ballast chambers are operated simultaneously. To flood the tidal chamber there are four 10-inch valves with horizontal stems situated 3 feet ¼ inch below the girder deck. Two 10-inch valves with vertical stems are used to flood the ballast chamber. All the main culvert valves are electrically operated. To drain these chambers there are two 6-inch valves in each, which empty into the ship berth. It was decided that the rolling caisson should be erected first as it could be used as a gate to protect the ship berth during construction. The contractors gave the Dominion Bridge Company permission to use the excavated part of the mouth of the berth as an erection site.

The rolling caisson was erected lying transversely across the berth, with its longitudinal centre line coincident with the centre line of its recess chamber. The floating caisson was also built here. Between the two caissons a large timber erection trestle was built to carry the erection car.

Before the Dominion Bridge Company started steel erection the contractors had placed the rollers in the floor of the berth. As it was necessary to caulk the seams of the caisson it was propped up on jacks 3 feet 6 inches above the floor of the ship berth and assembling was completed up to truss A. No great difficulty was experienced beyond that caused by ice and snow getting in the rollers.

At the recent annual meeting of the Commission of Conservation, a resolution was passed requesting the various provincial governments to take steps to secure complete reports of all losses from fires occurring within their boundaries, and the extent, if any, to which the property was insured.

A new invention has been patented in the United States the object of which is the production of timber, particularly piles, which shall be fully preserved for a part only of their length, that is, at the part where they are subject to decay. The method consists in first removing the outer bark from the entire length of the stick, and removing the skin, or inner bark from only that part which it is desired to impregnate with the oil under the usual or any preferred conditions of heat, vacuum, pressure, etc. Wood does not decay in that part which is permanently in wet soil, but the part in salt water is subjected to the destructive action of marine borers, and the part above the water line, and also the part which is alternately wet and dry, is subject to decay and fungous growth, dry rot, etc. Wood constantly submerged in fresh water does not suffer much from decay or insect life. Accordingly it is necessary to creosote piling to be used in fresh water only in that part from say 2 ft. below low water mark up to the top of the pile, while in the case of piling to be used in salt water the wood should be impregnated from a point say 4 ft. below the mud line to the top of the pile. Heretofore all piling used in this country, which has been creosoted at all, has been treated the full length, and on account of the fact that the small end or top of the tree (as it grows) contains a much larger percentage of sapwood than the butt, the end of the pile which goes into the ground has a much greater amount of oil, per cubic foot, than the butt, or in other words, the part of the stick requiring no preservative gets the greatest amount of preservative fluid. By the above process substantially no oil is used to impregnate that part of the wood which does not require preservation, the small amount absorbed apparently entering through small breaks or cuts accidentally made in the inner bark or skin. It is preferable to remove all the skin from that part of the length which it is desired to fully impregnate, but small pieces, say not greater than an inch wide by 5 or 6 in. long will not prevent substantially complete impregnation at these points.

ARTESIAN WELLS AND METHODS OF PUMPING THEM.*

By John D. Kilpatrick.

THERE has not hitherto been much discussion on the subject of the design, construction and operation of water supplies obtained from underground sources, particularly those from driven wells. In a great many localities the underlying formation is such that a water supply from a driven well system is impossible to obtain, but there are hundreds of situations where it is possible to obtain an artesian supply, and consideration should be given to this source, even when a filtration plant is available.

It is often stated that artesian supplies are not permanent in character. The writer disputes this point, because his experience, extending over a great many years, has led him to believe that the fault is not with the underlying water-bearing strata, but either with the construction of the wells themselves or to bad condition, due to neglect. There are many cases where the yield from the wells has steadily fallen off, and where it was possible, by developing the wells, and possibly changing the method of pumping, to bring the wells back to their original and sometimes to an even greater yield. . . . The writer refers particularly to wells driven through sand or gravel formation, where the use of a strainer is necessary. Of course, in the case of wells driven into the rock, it is only possible to obtain from any rock hole the amount of water contained or flowing through the crevices and fissures in the rock. With sand holes, however, the yield from any well is greatly affected by methods of construction and development of the well when drilled. The writer has drilled wells that yielded 15 gallons per minute which have been brought up to over 300 gallons per minute before being put into service.

In places where there is a choice between artesian well water and a surface water supply that has to be filtered before it is possible for the water to be used, more consideration should be given to an artesian supply if the cost of the plant and the cost of water delivered to the pressure pumps is close enough to allow of debate. This opinion is based solely on the ground of the purity of the supply. . . .

The writer refers particularly to the purity of supplies from driven wells, and admits at the same time that driven well water in almost every case is harder water than that obtained from surface streams. In very few cases, however, does driven well water have to be treated either to clarify or purify it. The installation of a filter plant for the clarification of a surface supply is not the end of that problem; ceaseless vigilance in the care of the filter is the only price of safety. There are localities where it is debatable whether an artesian supply is better and more economical to operate than a supply taken from a surface stream that is to be filtered, and still other localities where there are no surface streams, and the municipality is compelled to resort to artesian wells.

The problems involved in the laying out of an artesian well system may be grouped under three heads: (1) Location of the wells; (2) methods of drilling and construction; (3) methods of pumping. No consideration will be given in this paper to the methods of pumping from the pump-house up to the storage reservoir, nor to distribution systems. Only the delivery of the water to the suction basin in connection with the main pumps will be treated.

The location of the wells depends upon the extent and surface conditions of the land available for the well field. No rules can be set down for the proper location of wells until test-wells have been drilled, unless the underlying conditions are known from wells in the vicinity. In laying out a pumping plant which will obtain the supply from wells, as a general rule it is best to drill the wells and locate the pump on the lowest possible ground available. The obvious reason for this is that in drilling the wells we penetrate to the underground stream, and the object is to have the pumped level of the water as close to the surface as possible, because, as a general rule, it is more expensive per foot of pump head to deliver the water to the surface of the ground than from the surface reservoir up to the storage tank. If the well field is to be in a well-defined valley, it is preferable to drill the wells in a line across rather than parallel with the direction of the valley, because the underground stream of water may flow in the same general direction as the surface streams. This, however, is not always the case, and before locating definitely any number of wells, it is advisable to drill test-wells at various points.

There have been cases where city councils have taken the matter into their own hands, and have drilled wells on the summit of the hill on which they have decided to place the storage reservoir under the specious reasoning that if they could get a flowing well in the valley, they should get on top of the hill a flowing well, delivering its water freely into the storage reservoir, which would save the expense of pumping. Unfortunately, water will not rise above its source, and the money spent on drilling these altitudinous wells has been thrown away. There are places where it is possible to obtain flowing wells on the summits of high hills, but they are the exceptions which merely prove the rule.

In regard to the location of underground water supplies by the use of forked sticks, magnetic balls, pendulums, indicators for radio activity and other devices, the belief in such occult means is only evidence of the survival of a superstition of the alchemist's age.

The only scientific method of determining the location for a well is to obtain all the information possible about wells in the vicinity, together with all possible data regarding the underlying geological formations. A combination of experience with the aforesaid data and information is of considerable value. In addition to this information, test-wells should be drilled to the maximum depth considered necessary, and should not be less than 6 in. in diameter, so that a pump of reasonable size can be installed, and some conclusion drawn from the yield of the "prospect well." After these "prospect wells," the number of which will depend upon the local conditions, have been drilled and tested, sufficient data is at hand upon which to estimate the total number of wells that will have to be drilled to give the required yield. Great care must be taken to obtain an accurate record of all the formations passed through, and frequent tests must be made to determine the yield at different depths.

Driven wells may be roughly divided into two classes: (1) those where the water supply is obtained from the rock, and (2) those where the water-bearing strata lie above the rock. A third class might be added, a combination of these two.

(1) Where the rock lies at a short distance below the surface of the ground, and the quality of the water

*From the "Transactions" of the American Waterworks Association.

above the rock is unsatisfactory, the pipe should be driven so as to seat firmly into the rock, shutting off the surface water. The most satisfactory method of doing this work in the case of the 8-in. finished hole in the rock is to drive a 10-in. pipe down to the rock and drill a 10-in. hole in the rock far enough to be surely into the solid rock and below the shattered and seamy top surface. An 8-in. pipe should then be lowered to seat into the bottom of the 10-in. hole in the rock, and cement grout poured in sufficiently to fill up the annular space around the 8-in. pipe in the 10-in. hole in the rock. After this is set and the 8-in. hole drilled on in the rock, the 10-in. pipe may be withdrawn for use in another well.

During the drilling of the well tests should be made by means of sand bucket or working barrel to determine the yield at different depths. A good indication of passing through water-bearing crevices is the rise or fall of the standing water in the well. If continued drilling shows the same character of rock and the standing water level remains the same, it is a good indication that there is no great change in the possible yield of the well. Another indication of very little water in a rock well is shown by a great rise in the water-level in the well when the drilling tools are lowered.

When the well has reached the required depth, a test should be made, either with the working-barrel or the air lift. If there are a number of wells to be put in, the air lift system is to be adopted for the permanent pumping plant, and the test is made with a working barrel, it is advisable to place the working barrel at a point below the surface, so as to leave sufficient depth for the submergence of the air left. For instance, if the wells are 200 ft. in depth, the writer would not recommend that the working barrel be placed more than 100 ft. below the surface of the ground and the yield determined at this point.

(2) The construction of wells in sand or gravel. In driving wells through sand or gravel it is essential that the drive pipe be of strictly wrought iron and equipped with patent recessed couplings, and care must be taken so that the ends of the pipe butt in the couplings, and that the pipe be shod on the lower or cutting edge with a steel drive shoe. The reason for the pipe butting in the couplings is to carry the effect of the blow of the tools directly through the pipe to the drive shoe, instead of having the impact come upon the threads in the couplings.

The proper strainer and the placing of it is the next point to be considered. If the strainer is to be placed at the bottom of the well, this may be done either by driving the pipe through the water-bearing strata, introducing the strainer, and packing back the drive pipe so as to uncover it, or the drive pipe may only go to the top of the water-bearing sand, and the strainer pumped or driven into proper position. In the first case the strainer may be plugged before being lowered, but chances would be taken in the ability of the well-driller to jack back the drive pipe. In the latter case difficulty is sometimes found in placing the plug securely.

In either method of construction it is essential that means be taken to prevent sand from running up alongside the strainer between the top of the strainer and the well casing. This sand is kept out either by putting in a lead packer or by continuing an extra line of pipe from the strainer up to the surface of the ground. Where the lead packer is used the strainer is lowered into the hole, and in order to withdraw it any time considerable difficulty is usually found in getting hold of it and getting it out of the well without destroying the strainer. As a general rule, it is better to lower the strainer into place by means of piping extending all the way to the surface of the ground, and then, if it is necessary at any future time to withdraw the strainer it is a comparatively simple matter to do so.

In case the water is found in three or four strata with some difference between them, it is necessary to drive the pipe to the extreme depth, and then lower the strainers into place, with the proper connecting pipes between them, and then jack out the well casing at least as far as the top of the uppermost strainer.

The operation of jacking back pipe is one involving risk on account of the pipe parting under the strain. The only precautions that can be taken are to sand pump freely and frequently when the pipe is being driven, have the strainers on the ground, and lose no time in placing the strainers before jacking back the pipe, so that the sand and gravel will have as little time as possible to pack around the drive pipe couplings. Cutting the drive pipe may be resorted to in case it is unnecessary to withdraw the lower part of the drive pipe, which may have been driven to give the necessary amount of submergence in the case of an air lift well. The necessity of insisting upon the pipe being butted in the coupling is observed more particularly when jacking operations are required, because if the pipe is not butted there is even greater danger of stripping the threads. In case a pipe parts when being jacked back, it may result in a lost well.

(3) Under the third heading, where water may be obtained from the formations above the rock and from crevices in the rock, the construction of the well differs in no way from those referred to in the first two actions.

The pumping of driven wells may be done either by suction, deep well pumps, rotary or screw pumps, or the air lift. In case the water rises high enough in the wells to be pumped by suction, it is unnecessary to speak of this, other than to say that method of pumping is familiar to anyone who has ever done any hydraulic work. The only prime necessity for a successful suction plant is tight suction lines and good foot valves.

In regard to deep well pumps, these may be used when only limited supplies are required and where the water does not rise in the well high enough to make an air lift economical. The question of whether to use single-acting well heads with single-acting barrel, or single rods with double-acting barrel or double rod heads with double plungers depends entirely upon circumstances. Except under extreme conditions, the writer does not believe it advisable to use deep well pumps where there are more than two wells on account of the spacing between the wells, and the necessity of building separate pump-houses over each well, and for other obvious reasons of economical pumping.

For any number of wells scattered, as they usually must be, over quite an area, the air lift system has proven itself to be the most available method for delivering a large supply of water on the surface of the ground. It is not advisable, however, to use the air lift, except under extraordinary conditions, for delivering the water higher than to the level of the ground. At best, the air lift is an expensive way of pumping, but where the water is obtained in large volume below suction limits it would seem to be the only possible method. The air lift system has the great advantage of not having any moving parts in the well, and there is absolutely nothing to get out of order

in the air lift itself. The moving parts of the system are all in the air compressor in the engine-room, under the eye of the engineer. The engine-room may be located at the most convenient point, taking into consideration the supply of fuel, and the furthest well may be a mile or more away from the air compressor. If the air lines are correctly designed and properly buried, there need be but little loss of pressure. The main fault that the writer has found with a great many air lifts throughout the country has been in the air lift piping in the wells.

It is a familiar fact that a prime consideration for an economical air lift is that there should be 60 per cent. submergence. For instance, in a 100-ft. well there should be at least 60 ft. of water when the well is delivering its yield; but the principal trouble is found in the design of the air and water piping, so that the compressed air is delivered at the bottom of the uptake water pipe with as little loss by friction as possible, and that the uptake water pipe is designed so as to deliver the water, without being so large as to have an extreme amount of slip or so small as to develop excessive friction. Evidence of faulty design is shown by the discharge being in alternate pistons of water and air.

In a properly designed air lift system the water should be discharged in a practically uniform stream, with very little surging. A great many foot pieces have been designed which have for their object the spraying of air at the bottom of the uptake water pipe, so as to introduce the air into the water in streams of very fine bubbles. It was discovered early in the development of the air lift that the finer the spray could be made, other things being equal, the more efficient the air lift became; but no foot piece that was ever designed can work efficiently if the air pipe leading down to it, and the uptake water pipe from it, are not of such sizes as are suitable for the particular problem involved in that well. The great object to be accomplished by any foot piece is to offer as free and clear a water passage as is possible, so that there will be no eddies formed in the water column which cut down the velocity and impair the efficiency. Above the foot piece the mixture of air and water should have a pipe with as smooth surfaces as it is possible to obtain.

The three methods of piping wells may be termed: (1) The outside air pipe; (2) the inside air pipe; (3) the annular system. In the first case the air passes down outside the water pipe and into some type of foot piece or openings at the bottom with the water passing up through the inside of the water pipe. In the interior pipe system the air passes down the inside air pipe to a foot piece or nozzle, and the mixture of air and water is blown upward between the outside of the air pipe and the inside of the water pipe. In the annular pipe system one pipe is within the other, the space between the two pipes being the downtake air column, and the interior of the inside pipe being the uptake water discharge pipe. It is impossible without an exact knowledge of the conditions to determine which of these three systems it is best to use, assuming that the proper areas are available in each case for the amount of air necessary and the amount of water required to be lifted.

There are cases where the diameter of the well is so small and the amount of water to be delivered so large that there would not be room in the well for the outside air pipe, in addition to the uptake water pipe. In this case it might be better to use the well casing as the downtake air pipe, and only provide an uptake water pipe. This arrangement, however, is sometimes impossible on account of air leakage through the joints of the well casing, which were opened up when the well pipe was driven. It is very hard to generalize and lay down rules for piping up wells on account of the different yields, depths and submergence of wells, and this is sometimes still further complicated by the number of wells that have to be pumped.

With a great number of wells to be pumped from the same air compressor, very delicate adjustments are required so that all the wells may be started at the same time. The writer believes that it is preferable to use a single air line, with outlets to each of the wells, rather than separate air lines from the pump-house to each of the wells, both as a matter of economy of installation and economy in the use of air. The plea sometimes made that independent air lines to each well allow of adjustment within the engine-room is valid, because the place to adjust the well is at the well itself, and if the plant is properly designed originally, it should not be necessary to adjust the wells, except at considerable intervals of time, and then only because of the increased requirements made on the plant or fluctuations in the wells themselves.

Another rule, the observance of which should be insisted upon, is that the air lift should only be used to deliver the water high enough above the ground to allow of a flow to a surface suction basin close by the force pumps.

The writer has not referred to air pressure machinery, but considerable economies can be made in this part of an air lift system by installing compound and condensing machines and by two-stage air ends. The great loss of economy in the ordinary air lift system, however, is not in the engine-room, but in the air lift pump in the wells. Insufficient submergence, caused by pumping too great a quantity from the well and thereby lowering the head to a point where the increase in the amount of air necessary is out of all proportion to the quantity of water obtained, or by the use of piping either too large or too small. No foot piece ever designed will do the impossible, but a properly designed foot piece in connection with correctly designed air and water pipes will make the air lift an important factor in the pumping of deep wells, and a properly designed air lift system in connection with wells that have a good flow of water will result in pumping costs which will compare favorably with the cost of some surface water supplies that have to be filtered.

THE PIONEER OF HEAVY ELECTRIC TRACTION.

The first electric locomotive used for hauling freight was, according to Aera, the product of the ingenuity of Chas. J. Von Depoele. This locomotive was built by the Pullman Company and was put in operation in 1888. After about fifteen months' service it was scrapped, not because it was worn out or had outlived its usefulness as a freight carrier but because the owners found that passenger traffic paid higher dividends than heavy traffic. The motor developed 75 horse-power and was capable of hauling a maximum load of 35 tons.

As a preventive of disintegration in a large rock cut on the New York Central, the cement gun has been successfully used to apply a coating covering the rock and filling the external crevices so as to prevent further frost action.

The Department of Public Highways, Province of Ontario, has issued another edition, revised to date, of its rules for the guidance of road superintendents and engineers in county road construction and repair. These rules were originally published in 1911.

HIGHWAY BRIDGE DEVELOPMENT IN ONTARIO.*

By Geo. Hogarth, A.M.Can.Soc.C.E.

WE have to-day, sections in the south of the province that have been settled for over a hundred years; and in the north, there are vast areas where the axe of the first settler is only now being heard. Our bridge construction, therefore, varies from the most primitive types of timber construction suitable for the lightest of traffic to the more enduring structures of concrete and steel, which are capable of safely sustaining the weight of a twenty-ton road roller.

Our rivers of the north are usually broad and deep with nothing more secure than a shifting, slippery clay bank upon which to build abutments or piers. The crossing of such rivers is an expensive undertaking since the river bottom is frequently soft and very liable to be deeply scoured if the current is in any way deflected by a pier. In Ontario, hundreds of bridges are required each year, and those large structures which are more expensive and serve only a small population must frequently give way to less costly, smaller structures or ferries, which furnish communication till bridges are warranted. In deciding on the type of bridge to build, consideration must be given to the lumberman who is bringing sawlogs down the river, and piers must be located or omitted with a view to avoiding log jams. The safe location of the piers usually governs the length of bridge span to use, since the crowding of logs cannot always be prevented, and a heavy jam will often pull timber piers clean out of the river, piles and all. There is also the ice to contend with, and it works almost unceasingly to destroy any timber structure with which it comes in contact. Late in the fall, when the water is low in the river, the ice forms and sticks solidly to the piles or cribs for a depth of probably three to four feet. Should a sudden thaw come in February, the water lifts the ice and gives the piles a heave that throws the entire structure out of grade. For these reasons, it has been found advisable to bridge the rivers with one span wherever possible, and to place the abutments or piers out on the banks of the stream. The placing of piers in the river channel is usually an expensive piece of work, and the maintenance money that must be spent to protect them from logs and ice in the spring of the year is frequently considerable. The use of long-span bridges is therefore an economy.

On the smaller creeks and rivers, the timber queenpost bridge is still built and is supported by pile piers or timber rock-filled cribs; but where the bridge must be 60 feet or over in length, a steel span is the best and cheapest type of structure that can be built. The cost of labor in remote sections of the north is sometimes out of all proportion to the work done, and these types of construction have been developed from actual experience as being the most economical under present conditions. With such a type of bridge, the building of the pile piers requires comparatively little work, and four or five men and a team will finish the timberwork, erect the steel span and lay the floor of an ordinary structure in about three weeks' time. Many such bridges are built in locations which are 25 and 30 miles from a railroad, and local men accustomed to the country must be employed, since the ordinary discouragements of life on that class of work drive the new comer out of the business.

*Paper read before the 3rd Canadian and International Road Congress, Montreal, March 6-10, 1916.

The highway bridges built in the settled districts and counties of older Ontario are of a more advanced type of construction. They must be capable of carrying heavier loads and be built so as to withstand the wear and tear of greater traffic. Since good sand, gravel and crushed stone are easily obtained and cement is cheap, it is economical to build the structures of concrete. For the longer spans, where concrete is not as serviceable, the steel bridge is used, and it is customarily supported on concrete abutments and provided with a concrete floor.

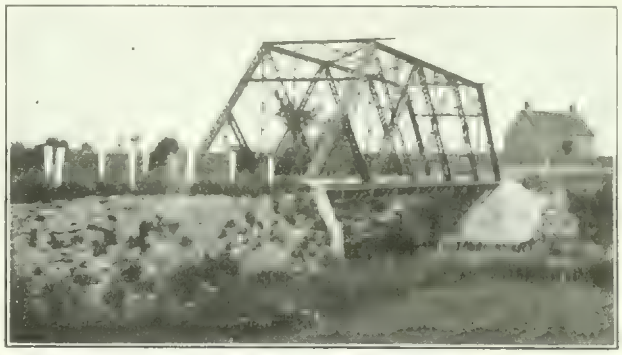


Fig. 1.—Steel Bridge Over Carter River at Charlebois.

For short spans, the concrete beam bridge is a very desirable structure, and for spans of medium length, where local conditions admit of its use, the concrete arch is of pleasing appearance. Such work, when well designed and properly built, is very durable, but great attention must be given to the foundations and to the surrounding conditions in order that damage to the structure may be prevented. Concrete is easily adapted to almost any foundation, but it is not in the best interests of such construction to use it in important locations where settlement of the piers is to be anticipated, or where the river channel will be cramped, due to a low bridge being required. The safety and enduring qualities of a concrete structure depend to a great extent on the stability of the foundations. The slightest movement of the footings will result in cracks opening in different parts of the structure, and while such cracks may not seriously affect the strength or safety of the bridge, they are unsightly and indicate an undesirable condition of affairs. Concrete is a splendid building material and will give good results even with very indifferent workmanship. It is particularly well adapted to certain locations and designs, but if used indiscriminately failures are bound to occur. In the case of small concrete bridges, the placing of the footings at a sufficient depth below the ground or water surface is frequently dis-

Fig. 2.—Thirty-foot Concrete Arch Bridge in Russell Township.

regarded. As a result, the rush of water during a freshet undermines the foundations and the entire structure may be lost. It is good practice to carry all footings down to a depth of at least four feet below low-water level since at that depth the foundation will be safe from frost as well as from the scouring action of the water. There are so many vital considerations entering into the design of a highway bridge that the selection of the type and nature of the bridge should be left entirely to the engineer and his decision should be final.

Fig. 3.—Concrete Beam Bridge Near Kearney.

Our highway bridges are now designed to carry a concrete floor and a 15 or 20-ton road roller, or a live load of 100 pounds to the square foot of floor surface. The structure which is built to carry such loading is of good proportions with fairly stout members. In the past, insufficient quantities of metal were used in many bridges and they were built so light as to be unable to ascertain for many years the wear and tear to which they were subjected by the traffic and the elements.

The tendency of the times indicates that a 20-ton road roller will be the maximum load for bridges for some time to come. In some localities it is proposed to limit the weight of road rollers and auto trucks allowed to pass over highways and to make the maximum permissible weight of such machines 10 or 12 tons. Legislation along such lines appears to be advisable since with an unrestricted weight of auto trucks we would soon see excessively heavy vehicles doing considerable damage to highway bridges. Some timber and concrete floors have already received severe treatment and have been partly destroyed by the heavy rear axle weight of loaded trucks, and unless steps are taken to curtail such weight the damage will greatly increase. It is advisable, therefore, to enact laws which will set a limit on these heavy loads so that the highway bridges can be built in the security of knowing the heaviest load they will be called upon to carry. Otherwise, great confusion may result, and a condition might arise where all our bridges would be too weak the moment an auto truck manufacturer increased the capacity and weight of his product. The establishing of a definite maximum load gives the auto builder and the bridge engineer a basis upon which to develop and improve all designs.

While we now build what is believed to be a fairly stout bridge, the required minimum thickness of metal of 5/16 inch causes nearly all highway bridge work to be known as tinwork in the shop where it is fabricated. If durable structures are to be constructed, no skimping or trimming out of metal should be allowed. It would appear to be a step in the right direction if no metal less than 3/8 inch thick was permitted to go into a highway bridge. Steel highway bridges are still built too light and flimsy to give a long length of life. Many steel bridges in use 25 years urgently require renewal to-day because of the serious rusting of the thin material, and if our work is to be enduring and have a fair length of life, it is absolutely essential that a sufficient quantity of metal be used in the new bridge.

When a bridge is to be built, accurate information is required respecting the width of the river, the depth of the water, the height of high and low water, the navigation or log driving to be provided for, the manner in which the ice goes out in the spring, the quantity of driftwood brought down by the freshet, the nature of the banks of the river, the character of the foundations that will be required, the local material available for concrete or timberwork, and the distance to the nearest railway station. This information is necessary, be the bridge small or large, and in addition the judgment of the engineer comes into play when the question is put as to what structure is best adapted to the site. Many instances could be cited where, owing to incomplete information, a bridge pier was placed in the middle of a river. The amount of money required to protect and maintain that pier, together with its first cost, would have paid for a steel bridge long enough to completely span the river. In some cases, bridges of insufficient length have been placed at crossings of wide rivers and as a result they have been swept away on the crest of the first serious flood. The position of the banks of a river is very significant. They are standing evidence that, at one time or another, the river possessed sufficient force and power to sweep away everything between those banks, and a structure which cramps that wide waterway is putting up a losing fight with nature. The pages of our engineering journals continually record the washing away of bridges, and the lesson frequently placed before us is that the waterways provided at bridges should be of a sufficient size to pass the floods. The creek of to-day may be the roaring torrent of to-morrow, and provision should be made for that excessive rush of water. It is only natural to build bridges as small as possible and to construct them with the least expenditure of money, but in building a bridge the first consideration should be the safety of the completed structure and the size of the waterway to be provided must govern the design.

The nature of the foundation on which the abutment of a bridge is to be placed deserves mention. An engineer

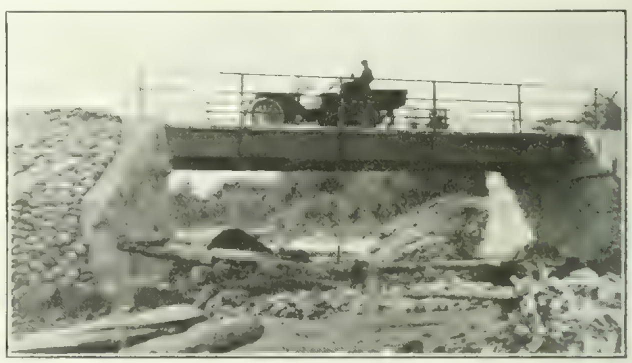


Fig. 4.—Steel Beam Span on Rubble Stone Abutments Near Sault Ste. Marie.

is called upon to construct bridge footings in every kind of location from one that is a bottomless bog to one that is splendid solid rock. There are between those extremes a number of different classes of material, all of which require close attention in order that a secure footing may be obtained. A solid rock foundation is ready for the concrete as soon as all the loose and decayed rock has been blasted and cleaned away. It is well to have the

rock footing fairly level and yet rough enough to give the concrete a good bond to prevent any possibility of sliding.

With a foundation of gravel, boulders, or hardpan, the concrete of the footing may be deposited when the excavation reaches a depth of four or five feet, since at that depth scouring of the material cannot occur and frost will have no effect.

In some locations where an exceptionally soft foundation occurs, it is advisable to divert the road to a better crossing, where a more secure bottom can be obtained. With a highway bridge, however, there is a lack of vibration and impact and the loading is comparatively light, so that in almost all soft locations a good pile footing will be found to be all that is required to safely carry the abutment.

For short bridges up to, say, 40 or 45 feet in length, and where the bottom is soft, a steel beam bridge gives a very satisfactory structure. The small cost of the entire work does not justify expensive pile foundations, and a mat composed of long timbers may be laid in the bed of the river so that each timber extends under both abutments.

A slight settlement is to be expected with such a structure, but no harm or damage to the bridge will occur.

The maintaining of the many steel bridges now on the highways is a work requiring considerable experience and attention. A bridge is like any other structure built by man—it is not everlasting. In the case of steel structures, it has practically been a custom to neglect them and they are seldom painted. This neglect hastens the rusting and decay of the metal, and the day soon comes when another bridge is necessary. It is frequently a difficult matter to have councils appropriate money for painting bridges when they have seen indifferent and expensive work done on bridges in their own or in an adjoining municipality. There is no doubt whatever that money spent for painting is real economy, and there is no defence that can be offered for allowing a bridge to go to ruin. If a structure is painted every four years, it will take five complete paintings to protect it for 20 or 25 years, and at the end of that time it should be in a good state of preservation.

Fig. 5.—Concrete Beam Bridge in Cumberland County.

It could then be removed to a highway having lighter traffic and would probably be of good service in that new location for a number of years. Experience with bridges that have been uncared for for 25 years, indicates that they are just about ready for the scrap heap; whereas, proper painting, carried out at comparatively small cost, would have rendered them still useful for an indefinite period.

The practical test of observing the bridge during the passage of a heavy load may result in the discovery that the various parts appear to be loose and that the entire structure appears to be working or moving. If there are a number of adjustable members in the trusses and lower laterals, it is probable that the tightening of such while no load is on the structure will cure any apparent looseness, while if the bridge is fully riveted it is desirable that close attention be given the various joints to see that rivets are still tight. If a number of loose rivets are

Fig. 6.—Steel Bridge with Reinforced Concrete Trestle Approaches, all Supported on Concrete Piles.

found, it is best to cut them out and re-drive so as to produce a tight joint.

In Ontario, we have many concrete bridges, and where such structures were originally well built there are no maintenance charges and little or no inspection required. The first concrete arch bridge built by the Department of Public Works was constructed in 1907. It is founded on solid rock, and to date not one cent has been expended for maintenance.

In conclusion, it may be said that the highway bridge is to-day in an important stage of development. The knowledge gained in using the various materials of construction is tending to modify and improve the design and general appearance of such structures, and a more artistic type is being aimed at. With an established system of loads for all structures, and a greater public demand for permanency in construction, a considerable improvement in the character and type of bridges is to be expected.

An endless chain operated by an electric motor is used in loading ties for shipment from a Texas lumber camp. Two men place the ties on the chain at one end and two men remove them at the other end and place them on the car.

The large amount of zinc required for war purposes, and the resulting enormously increased demand for the metal, lend special interest to an article in the current number of the Bulletin of the Imperial Institute, on "The Occurrence and Utilization of Zinc Ores." The chief zinc minerals are described, and a brief account given of the more important occurrences in the United Kingdom, the Colonies and India. Zinc ores have been mined in many parts of the United Kingdom, notably in Cumberland, Northumberland, Durham, Derbyshire, Shropshire and the Isle of Man, but a large proportion of the production has for several years past been shipped to the Continent for smelting. By far the most important zinc deposits in the British Empire are those of Broken Hill Mines, New South Wales, the output of which alone is sufficient to supply the entire demands of the United Kingdom for metallic zinc. The Broken Hill ore before the war went mainly to Germany for smelting, but the Australian Government has adopted measures which will prevent this in the future. Zinc is also found in South Australia, Queensland, Tasmania, New Zealand and Newfoundland. Canada contains a number of workable zinc deposits, particularly in British Columbia, and there is every prospect of Burma becoming an important producer. In Africa there are zinc deposits in Egypt, Nigeria, Rhodesia, and the Transvaal, as to which more information is needed.

FIELD AND OFFICE METHODS EMPLOYED BY THE HYDROMETRIC SURVEY OF CANADA.

In the recent report of Progress of Stream Measurements in Canada, which has been prepared under the direction of F. H. Peters, M.Can.Soc.C.E., by the chief hydrometric engineer, P. M. Sauder, M.Can.Soc.C.E., and assisted by G. H. Whyte and G. R. Elliott, A.M.Can.Soc.C.E., some information on stream-gauging is given. The theory involved is not new, but a great wealth of detail as to the application of it makes it very interesting and instructive, both to the student and the practising engineer.

Stream Measurements.—There are three distinct methods of determining the surface flow of streams: (1) by measurements of slope and cross-section and the use of Chezy's and Kutter's formulæ; (2) by means of weirs, which include any device or structure that by measuring the depth on a crest or sill of known length and form, the flow of water may be determined; (3) by measuring the velocity of the current and the cross-section. The third method is the one most commonly used by this survey. The second is used when the flow

Gauging Station on Old Man River, near Cowley, Alta.

is too small to be accurately determined by the third, while the first is only used in making estimates of the discharge of a stream when the only data available are the cross-section and slope. The slope method of determining discharge will not be discussed, as it is only approximate. The weir method is applied for small streams. Few permanent weirs have been installed by the survey. Many weir measurements have been made by means of temporary weirs, which consist of a wooden base of 2-inch plank with a rectangular notch of ⅜-inch steel bolted to it. The edge of the steel is bevelled. Care must be exercised in erecting the weir properly and in the choosing of a good location for it. The depth of water on the crest should not exceed one-third the length of the weir. The approach channel should be several times as wide as the opening, and the depth of water in the pond should be twice that over the crest so as to eliminate velocity of approach and cross-currents.

The dam in which the weir is set should be at right angles to the direction of flow. Sods are generally used in its construction, and precautions must be taken to prevent undermining. When the bay has filled up the head of water is determined by taking levels at the crest of the weir and at the level of the bay, from 4 to 10 ft. upstream; the difference of these gives the head operating at the weir.

After determining the head the discharge is computed by using the following formula, which is a modification of Francis' formula for rectangular, sharp-crested weirs: $\phi = 3.33\ (L - .2H)\ H^{3/2}$, in which ϕ = discharge in sec. ft.; L = length of crest in ft., H = head in ft.

Measurements by means of temporary weirs should be made some distance above or below the gauge. If they are made close to a gauge, the gauge must be read before the weir is placed in the stream, and the pond must be allowed to run off after the weir is removed before the gauge is re-read.

Where permanent weirs are installed, the gauge height observed is that of an auxiliary gauge above the weir, which is kept so that the head of the weir can be read direct. The weir is not usually placed so that it will interfere with the regular station, so that if at any time the weir is destroyed the regular gauge can be read during the period that the weir is out of order.

The velocity method of determining the discharge of a stream is the most accurate. There are two methods of determining the velocity of flow of a stream, namely, direct and indirect. In the direct method, by which the velocity is determined by means of floats, the liability of error is large and the results far from satisfactory. This method is seldom used except for very rough estimates, or when a current meter cannot be used.

The indirect or current meter method is the most reliable and most widely used method of determining the velocity of the flow of a stream. The meter used by this survey is the Price Patent, manufactured by W. & L. E. Gurley, Troy, N.Y. It consists of six cups attached to a vertical shaft, which revolves on a conical, hardened steel point when immersed in moving water. The number of revolutions is indicated electrically. The rating or relation between the velocity of the moving water and the revolutions of the wheel is determined for each meter by drawing it through still water for a given distance at different speeds and noting the number of revolutions for each run. From this data a rating table is prepared which gives the velocity per second of moving water for any number of revolutions in a given time interval.

In making a measurement with a current meter, a number of points, called measuring points, are measured off above and in the plane of the measuring section, at which observations of depth and velocity are taken. These points are spaced equally for those parts of the section where the flow is uniform and smooth, but should be spaced unequally for other parts according to the discretion and judgment of the engineer. In general, the points should not be spaced farther apart than 5 per cent. of the distance between piers, nor farther apart than the approximate mean depth of the section at the time of measurement.

The measuring points divide the total cross-section into elementary strips, at each end of which observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the ends, the width of the strip, and the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream.

There are a number of different methods of determining the mean velocity at the ends of these strips, or, as it is commonly called, the mean velocity in a vertical, namely, multiple-point, single-point, and integration. These three principal multiple-point methods in general

use are the vertical velocity-curve, three-point and two-point method.

In the vertical velocity-curve method the centre of the meter is held as close to the surface of the water as possible, being careful to keep it out of reach of all surface disturbances, and then at a number of different depths throughout the vertical. The velocity at each position of the meter is recorded. These observations are then plotted with velocities in feet per second as abscissae and their corresponding depths in feet as ordinates, and a mean curve is drawn through the points. The mean velocity for the vertical is obtained by dividing the area bounded by the curve and its axis by the depth. In the absence of a planimeter for measuring the area, the depth is divided into 5 to 10 equal parts, and the velocities of the centre ordinates of these parts are noted. The mean of these velocities will very closely approximate the mean in the vertical.

The vertical velocity curve is useful in studying the manner in which velocities occur in a vertical. From a study of a number of these curves the other shorter methods of determining mean velocity are deduced. On account of the length of time taken to complete a measurement this method is not used in general routine measurements, except during the winter, for a change of stage is almost sure to occur during a measurement on a large stream, which counterbalances the increased accuracy. For this reason its use is limited to the determination of the coefficient to be used in the reduction of values obtained by other methods of measuring velocity to the true value, to the measurements of velocities under new and unusual conditions of flow, and for measurements under ice.

The three-point method is one of the short methods of obtaining the mean velocity in the vertical, and, under some conditions, gives the most accurate results next to the vertical velocity-curve method. It has been used almost exclusively by this survey in past years, during the open-water period, but recently has been superseded by the two-point method, which, under most conditions, gives more accurate results. In the three-point method the current-meter is held at 0.2, 0.6, and 0.8 depth. The mean is then obtained by dividing by 4 the sum of the velocities at 0.2 and 0.8 depth, plus twice the velocity at 0.6 depth.

In studying the vertical curves made at a number of different points and under varied conditions, it has been found that the mean of the velocities occurring at 0.2 and 0.8 depth gives very nearly the mean velocity in the vertical. Use is made of this fact in the two-point method of determining mean velocity, the meter being held at 0.2 and 0.8 depth in the vertical. This method has been found more accurate than the single-point method, and the time required for a metering is not very much greater. This method has been found to give, also, a very close approximate to the mean velocity in measurements of ice-covered streams, although these flow under very different conditions from those of open water.

The single-point method is based on the results of experiments, which have established the point of mean velocity in a vertical at 0.6 of the depth. Therefore, the error resulting from the use of the 0.6 depth as the depth of mean velocity is very small, though in some few cases a study of the vertical velocity-curve will show the need of a coefficient to reduce the observed velocities to the mean. The variation of the coefficient from unity in individual cases is, however, greater than in the two or three-point method, and the general results are not as satisfactory. For that reason this method is not employed very extensively by the survey.

In the other principal single-point method the meter is held near the surface, at from 0.5 to 1 foot below the surface, care being taken to sink the instrument below the influence of wind or waves. The resulting velocities must be multiplied by a coefficient to reduce them to mean velocities. This coefficient, as found by a large number of experiments, varies from 0.78 to 0.98, depending upon the depth and speed of the stream. The deeper the stream and the greater the velocity, the larger the coefficient. In flood work coefficients varying from 0.90 to 0.95 should be used. This method is only used when the current is too strong to permit the sinking of the meter to any great depth below the surface of the water. It is often employed at times of flood, or when a stream is carrying a lot of driftwood or ice.

The integration method of determining the mean velocity in a vertical consists in moving the meter at a slow, uniform speed from the bed of the stream to the surface and return in a vertical direction, the time and revolutions being observed. In travelling through all parts of the vertical the meter is acted upon by each and every thread of velocity from the bed to the surface of

Gauging Station on the North Branch of Milk River.

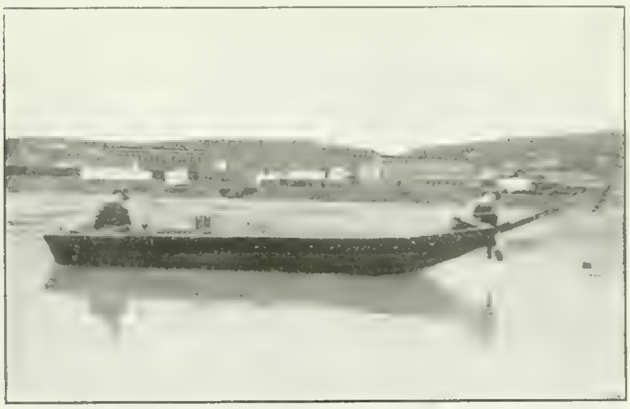
the stream, and the resulting observations determine the mean in that vertical.

This method is very useful in checking the results of other methods. It is, however, seldom used by this survey, as the Price meter is not suited to observations by this method, since the vertical motion of the meter causes the wheel to revolve.

Gauging Stations.—The location of gauging stations is very important, and the choosing of a suitable place is more difficult than one would think. Not only must the water be moving in nearly straight lines over a solid bed and between well-defined banks, but the place must be accessible at moderate cost, and there must be living near it a competent person who can be engaged to serve as observer. Permanent gauging stations should only be selected after a very thorough reconnaissance. In the irrigation districts and in more thickly populated districts there is more or less diversion of water. This is apt to complicate matters for the hydrometric engineer, for a gauging station above all works may not include all the tributaries of the stream, and it is often necessary to establish gauging stations at several points along the streams, and on tributaries, canals, and pipe lines in order to obtain complete information regarding the water supply in a particular stream.

There are three classes of gauging stations, namely, wading, bridge and cable stations. The wading station can, of course, only be used in the case of small streams having a maximum depth at its highest stage of three feet or less. The equipment for a wading station is small, consisting usually of a plain staff gauge, graduated to feet and hundredths, and fixed vertically to one of the banks of the stream. For convenience a measuring line, usually a wire with tags, may be fixed permanently at this section. When taking the reading the engineer should stand below and to one side of the meter so as not to cause eddies in the water.

Bridge stations, because of their permanency and the freedom of movement allowed the engineer, are much preferred. Very often, however, more particularly in swift currents, the piers materially affect the accuracy of the results. When the gauge cannot be attached to a pier, it is often attached horizontally to the guard-rail or floor of the bridge, and the height of the stream is found by lowering a weight by a chain over a pulley. It is indicated by a marker on the chain. Distances of three, five or ten feet, according to the size of the stream, are



Boat used for making Discharge Measurements of Athabaska River at Athabaska, Alta.

marked on the lower chord of the down-stream side of the bridge to serve as a measuring line.

Frequently it is impossible to establish a permanent gauging station at a bridge. In that case the wire cable of a ferry can be utilized, or, if that is not available, a permanent wire cable is stretched across the river. For spans of average length a galvanized wire cable ¾-inch in diameter is safe. It is supported at each bank by means of high struts or by passing it through the crotch of a tree. The cable is run into the ground and anchored securely to a "dead man," buried at least six feet below the surface, or, if convenient, it is anchored to the lower part of the trunk of a tree. A turnbuckle is inserted in the cable between the strut and anchorage to permit tightening the cable when it begins to sag. A permanent measuring line, usually a wire, with tags 5 or 10 feet apart, is stretched across the stream just above the cable. A cage large enough to carry two men and instruments is constructed and suspended from the cable by means of cast-iron pulleys. The cage is moved from point to point by hand. A stay-line, usually quarter-inch guy wire, is stretched across the stream about 30 to 40 feet upstream from the cable, and securely fastened. By passing a sash-cord through a pulley hung on this stay-line the current meter is prevented from being carried downstream. This type of station has the advantage that it can usually be located at the most desirable point on the stream and is free of piers and other obstructions.

Owing to friction in the current meter the lowest velocity at which readings can be depended upon has been found from experiment to be 0.5 ft. per sec.

Office Computations.—When a series of discharge measurements has been made at a gauging station a rating curve is constructed for that station, showing graphically the discharge corresponding to any stage of the stream within the limits covered by the gaugings. This curve, as it is usually drawn, has as abscissae the discharges in second-feet, and as ordinates the corresponding gauge heights at which the discharges were made. A smooth curve is drawn through the resulting set of points, and from this curve the discharges at any stage within the limits of the curve are taken. Some measurements may be more reliable than others, owing to more or less favorable conditions at different times of gauging, or to other causes. In order to obtain the weight of the different measurements, curves with area and mean velocity, as abscissae, and gauge heights as ordinates, are also drawn. From a study of these curves any discrepancies in a measurement, either in its area or mean velocity, may be detected. A station rating table is prepared after the rating curve is constructed which gives the discharge at any stage of the stream within the limits of the daily gauge height observations on record. From this rating table the daily discharges corresponding to the daily gauge heights are read and tabulated. The rating table is constructed for tenths, half-tenths, or hundredths of feet, according to the readings of the gauge to which it is to be applied. The discharges for this table are read directly from the rating curve and are then adjusted so that the differences for successive stages shall be either constant or gradually increasing, but never decreasing, unless the station is affected by backwater.

The rating table being made to cover the range of daily gauge height observations, the next procedure in the computations is to make out a table of daily discharges from this rating table. The daily gauge heights are copied as they were sent in by the observer, and opposite each the corresponding discharge is filled in from the rating table. The monthly discharge is found by totalling the daily discharges for the month in question, and the monthly mean is obtained by dividing this total by the number of days in the month.

The run-off is computed with two different sets of units, depending upon the kind of work for which the data is intended, as follows:—

1. Run-off in inches is the depth to which a plane surface equal in extent to the drainage area would be covered if all the water flowing from it in a given time were conserved and uniformly distributed thereon; it is used for comparing run-off with rainfall, which is usually expressed in depth in inches. The monthly mean run-off in second-feet is divided by the area of the drainage basin in square miles to find the monthly mean run-off per square mile. This result, reduced to run-off in depth in inches for the monthly period, is in the form required.

2. The run-off in acre-feet is the form of most use in connection with storage. An acre-foot is equivalent to 43,560 cubic feet, and is the quantity of water required to cover an acre to the depth of one foot. The monthly mean run-off in second-feet is used for the computation of run-off in acre-feet. The monthly mean is reduced to cubic feet per month, and this quantity, divided by 43,560, gives the run-off in acre-feet.

The run-off of the stream being computed both in depth in inches and in acre-feet for each month, the run-off for the period during which observations of run-off were made is found by the summation of the amounts of run-off for the several months making up this period.

Winter Records.—Perhaps the greatest difficulties in stream measurements are met with in the early part of the winter, just as the streams are commencing to freeze up. Especially is this true in the swift-running streams in or near the mountains. Needle and anchor ice often form in large quantities in rapids, and, flowing in masses with the water, make gaugings very difficult and unreliable. Even after a permanent ice cover is obtained at the gauging station this ice will, in some cases, obstruct the channel below the station and cause "backwater."

A further difficulty is that the surface ice usually forms along the edges of the stream for some time before forming in the centre of the channel. At first this may be broken away if the stream is small and open-water measurements made, but later it is necessary to take some observations through holes in the ice along the edge. As the streams get farther away from the mountains their velocity decreases, and fewer rapids occur along their course. There is then less trouble with needle and anchor ice, and a permanent ice cover forms much more quickly.

It is often necessary to choose a new section for winter observations. This should be done before freeze-up, for then the width, depth, uniformity of flow and conditions above and below can be easily noted. The most suitable stations for winter measurements are those which have a long stretch of very smooth, sluggish water above and a rapid fall below.

In winter as in summer, the daily discharges of a stream are computed from frequent discharge measurements and daily gauge height observations. The discharge measurements are made through holes in the ice from five to ten, or even twenty feet apart, depending upon the size of the stream, and large enough to allow the current meter to pass though freely. The gaugings are made in the same manner as at open sections except that the depth of the stream is taken as the distance from the bottom of the ice to the bed of the stream. The soundings, however, are always referred to the surface of the water in the holes, the distance from the surface of the water to the bottom of the ice being measured and subtracted from the soundings to obtain the depth.

The vertical velocity-curve method is usually used for the determination of the mean velocity in the vertical. A curve is plotted for each vertical, and/the mean velocity is determined in the usual manner. These curves vary greatly as to form for different kinds and conditions of channel.

It is found that when all the holes are opened on a small, swift stream there are sometimes vertical pulsations of the water in the holes, which affect the velocity readings. This can usually be avoided by only opening one hole at a time, and filling it in again with ice and snow as soon as the observation is finished. It can also be overcome by inserting a thin sheet of galvanized tin or iron at the bottom of the hole after the meter has been lowered into the water. The meter should always be held near the upstream side of the hole.

In using the meter care must be taken to keep it under the water as much as possible to prevent ice from forming around the bearings. It is a good plan to clean and oil the meter indoors before starting out to make a gauging.

Gauge Observations.—The gauge is usually read once a day, the observer cutting a hole in the ice and noting the elevation of the water and gauging the thickness of the ice by means of an L-shaped ice-gauge. Notes are taken as to needle ice, slush, snow, ice-jams, and any sudden temperature changes.

Any form of gauge may be used, but the chain-gauge is the most satisfactory, as the staff-gauge, being frozen to the ice, heaves with it, and also in cutting away the ice from around it the figures are effaced. The automatic gauge gives trouble with the well freezing over.

While the run-off, particularly during the winter months, does not vary directly in accordance with the precipitation, the rate at which it reaches the streams is, of course, dependent almost entirely upon the climatic conditions.

There is, therefore, very little surface run-off, and ern Canada which make it exceptionally difficult to make estimates of the daily discharge during the winter. The gauge height in many cases fluctuates very much, and often sudden rises or drops occur. These rises are often

Gauging Station on Frenchman River.

explained by the fact that during very cold spells a great deal of slush, frazil and anchor ice is formed and chokes up the channel, thus raising the surface of the water, when in reality the discharge is decreasing. Then, again, a chinook causes a sudden rise in temperature and the discharge is often increased, while at the same time the gauge height gradually lowers, evidently because the warmer weather and water have melted out a lot of the ice from the channel and given it a greater carrying capacity.

In order to make reliable estimates of the daily discharge, gaugings must be made at short intervals and the weather conditions and temperatures in the whole of the drainage area above the stations must be very carefully studied.

The weather conditions and temperatures at the gauging station are not always typical for the whole drainage basin above, and care must, therefore, be taken to have the meteorological observations made at some other place, or, if necessary, at two or more places. Of course, care must be taken to study all the possible conditions which may affect the estimates.

LETTER TO THE EDITOR.

Stresses in Lattice Bars of Channel Columns.

Sir,—The writer was much interested in the discussions by Mr. Goodrich, Professor O. H. Basquin and others. I take it from their articles that they are just as anxious as myself to have this problem settled, and therefore wish to bring out clearly the principle upon which my discussion is based. I have assumed the following:—

1st. As the length l approaches zero, the stress in the column due to bending also approaches zero.

2nd. As the length l becomes greater, then the stress in the column due to bending also increases.

3rd. That it is only the stress due to the bending of the column that causes any material stress in the lattice bars.

4th. That all columns centrally loaded have a tendency to bend into the shape of a sinusoid whose equation is $y = \Delta \sin n \pi \frac{x}{l}$ as shown in Figs. 1, 7 and 8. (See Merriman's "Mechanics of Material," 1894 edition, page 115.) [Editor's Note—Figs. 1 to 6, inclusive, and Equations 1 to 18, inclusive, appeared in the February 24th, 1916, issue of *The Canadian Engineer*.]

5th. If we know the flange stress in the centre of the column due to bending, and plot a sinusoid whose centre ordinate is equal to that stress, then any ordinate taken at any point x (see Fig. 9) will be equal to the stress in the channel at that point due to bending.

6th. If the column (hinged top and bottom) is divided into, say, twelve equal parts, then the ordinates will have the relative proportions to the centre ordinate, as shown in Fig. 9.

If the six assumptions given above are correct, the problem resolves itself into a very simple one. If the column is hinged each end (or round ends) then the equation is

$$y = \Delta \sin \pi \frac{x}{l} \quad \text{(See Figs. 1 and 9.)} \quad \text{[Equation 19.]}$$

If the column is hinged at bottom and fixed the other,

$$y = \Delta' \sin \frac{3}{2} \pi \frac{x}{l} \quad \text{(See Fig. 7.)} \quad \text{[Equation 20.]}$$

If the column is fixed both ends,

$$y = \Delta'' \sin 2\pi \frac{x - \frac{l}{4}}{l} \quad \text{(See Fig. 8.)} \quad \text{[Equation 21.]}$$

The case under discussion is the one shown in Figs. 1 and 9, Equation 19.

Now, referring to the 5th assumption, all that it is necessary to do is to substitute for Δ in Equation 19 the stress in each channel due to bending of column at the centre of the column. One will then get ordinates as shown in Fig. 9.

The ordinate y at any distance x will then be the stress in the channel at that point due to the bending of the column. If a stress curve is plotted as shown in Fig. 9, then it is possible to get the stress in any lattice bar.

The problem now resolves itself into getting the most correct column formula for the stresses in columns.

If the same notation is followed as called for in my February 24th article, S_c = 16,000 lbs. per sq. in. (safe pressure per sq. in.); S = 50,000 lbs. per sq. in. (ultimate pressure per sq. in.); E = 29,000,000 (modulus of elasticity). (S and E are values given in Cambria and Carnegie handbooks.)

Then,
$$S' = \frac{S_c}{1 + \frac{S}{m \pi^2 E} \frac{l^2}{r^2}}. \quad \text{[Equation 22.]}$$

Substitute values given above and $m = 1$ for round ends, then

$$S' = \frac{16{,}000}{1 + \frac{1}{5{,}800} \frac{l^2}{r^2}}. \quad \text{[Equation 23.]}$$

(Note—Equation 23 is very nearly the same as that which was suggested by Mr. Goodrich, and is what Professor Merriman gives.)

Referring to Equation 19, we get

$$y = \Delta \sin \pi \frac{x}{l}.$$

Now, if in this equation we substitute for Δ the value

$$(S_c - S_1) \frac{A}{2},$$

the equation becomes

$$y = (S_c - S_1) \frac{A}{2} \cdot \sin \pi \frac{x}{l} \quad \text{(See Fig. D.)} \quad \text{[Equation 24.]}$$

It will be noticed that Equation 24 is the same as Equation 16, except that I have substituted $\frac{A}{2}$ for A. This error was pointed out by Professor Basquin, and also by Mr. Goodrich.

Equation 24 gives the equation of the curve shown in Fig. 9 and similar to that shown in Fig. 1.

If ϕ is the angle the lattice bars make, then the stress in the end lattice bar $b\,c$ =

$$(S_c - S_1) \frac{A}{2} \sin \pi \frac{x}{l} \sec \phi. \quad \text{[Equation 25.]}$$

There are two lattice bars, so the stress in each end lattice bar becomes

$$b\,c = \frac{(S_c - S_1) \frac{A}{2} \sin \pi \frac{x}{l} \sec \phi.}{2} \quad \text{[Equation 26.]}$$

But ϕ is usually 60°, and sec of 60° is 2,

Therefore, $b\,c = (S_c - S_1)\frac{A}{2} \sin \pi \frac{x}{l}$. [Equation 27.]

Equation 27 is the same as given in my February 24th article under Equation 16, except that $\frac{A}{2}$ has been substituted for A.

(Note—y given in Equation 24 is the stress in the channel at any point x, but as ϕ is usually 60°, and secant of 60° is 2, also as there are two lattice bars, therefore when ϕ = 60°, then the stress in each end lattice bar $b\,c = y$, when x is the distance to the first rivet from the end.)

Referring to Fig. 9 and the 5th assumption.

The stress in the centre of the column in each channel will be $(S_c - S') \frac{A}{2}$.

If this quantity is taken as the centre ordinate and a sinusoid plotted, then the stress in the channel at any point x will be equal to the ordinate y and will be the stress shown as p in the end panel.

This assumption is based on the same theory as an ordinary lattice truss having an evenly distributed load in which, if the centre ordinate is made equal to the stress in either flange and a parabola is plotted, then the stress at any other point x is obtained by simply scaling off the ordinate.

It seems reasonable that if the stress in an ordinary lattice truss is proportional to the deflection curve, then the same law should apply to columns.

Referring now to Fig. 7.

The same method may be adopted by using Equation 20, and for Δ' substitute $(S_0 - S')\frac{A}{2}$, finding S' by Equation 39.

Referring to Fig. 8.

Equation 21 must be used and for Δ' substitute $(S_0 - S')\frac{A}{2}$, finding S' by Equation 43.

Transverse shear may be found as follows:—

Referring to Fig. 1. M = bending moment at centre of column. Then,

$$M = P\Delta. \quad \text{[Equation 29.]}$$

Total stress in one channel due to M is

$$(S_c - S_1)\frac{A}{2},$$

Therefore, $\frac{P\Delta}{D'} = (S_c - S_1)\frac{1}{2}$,

and $P\Delta = D'(S_c - S_1)\frac{1}{2}$. [Equation 30.]

Also, $m = Py$. [Equation 31.]

Substitute for y the value given in Equation 19, then

$$m = P\Delta \sin \pi\frac{x}{l}. \quad \text{[Equation 32.]}$$

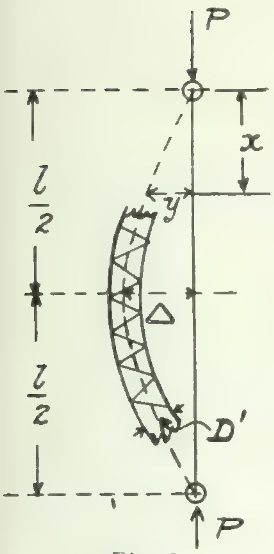


Fig. 1.
Round ends.
$n = 1$.

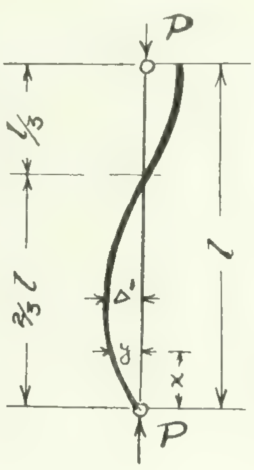


Fig. 7.
Top fixed,
bottom round.
$n = 3/2$.

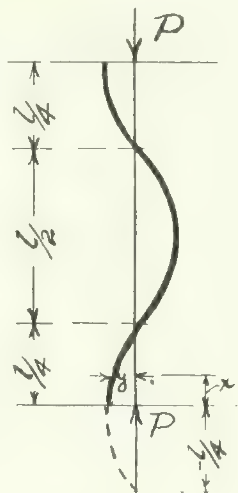


Fig. 8.
Both ends
fixed.
$n = 2$.

We know that $\frac{dm}{dx} = V$, where V is the shear. Differentiating Equation 32 we get

$$dm = P\Delta \cos \pi\frac{x}{l}\,\frac{\pi\,dx}{l}, \text{ or}$$

$$\frac{dm}{dx} = P\Delta\frac{\pi}{l}\cos\pi\frac{x}{l} = V. \quad \text{[Equation 33.]}$$

Equation 33 gives the transverse shear at any point x, and if $x = 0$, we get

$$V = P\Delta\frac{\pi}{l}. \quad \text{[Equation 34.]}$$

If, in Equation 34, for $P\Delta$ is substituted value found in Equation 30, then Equation 34 becomes

$$V = D'(S_0 - S_1)\frac{A}{2}\,\frac{\pi}{l}. \quad \text{[Equation 35.]}$$

Equation 35 gives transverse shear; round ends.

Referring to Fig. 10, Cambria gives the following values with reference to axis 2-2:—

7" channel	$D' = 6\frac{3}{4}$"	$r = 2.8$	$A = 5.7$
10" "	$D' = 9\frac{1}{4}$"	$r = 3.83$	$A = 8.92$
12" "	$D' = 11\frac{1}{4}$"	$r = 4.64$	$A = 12.06$
15" "	$D' = 13\frac{1}{4}$"	$r = 5.61$	$A = 19.8$

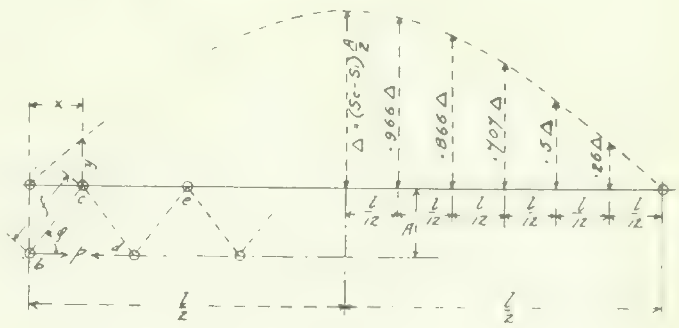


Fig. 9.

When $l = 9'\,0''$, then for 7" channel columns, $\frac{l}{r} = 38.6$, $\frac{l^2}{r^2} = 1{,}490$.

When $l = 12'\,0''$, then for 10" channel columns, $\frac{l}{r} = 37.6$, $\frac{l^2}{r^2} = 1{,}414$.

When $l = 15'\,0''$, then for 12" channel columns, $\frac{l}{r} = 38.8$, $\frac{l^2}{r^2} = 1{,}465$.

When $l = 18'\,0''$, then for 15" channel columns, $\frac{l}{r} = 38.6$, $\frac{l^2}{r^2} = 1{,}490$.

The above values for $\frac{l}{r}$ are very nearly what is given in Bulletin No. 44 for column No. 1, which was $\frac{l}{r} = 37.8$.

Substituting above values in Equation 23, the following is found for S':—

7" channel column 9' 0" long, $S' = 12{,}730$; therefore $(S_0 - S_1) = 3{,}270$.
10" channel column 12' 0" long, $S' = 12{,}850$; therefore $(S_0 - S') = 3{,}150$.
12" channel column 15' 0" long, $S' = 12{,}750$; therefore $(S_0 - S') = 3{,}250$.
15" channel column 18' 0" long, $S' = 12{,}730$; therefore $(S_0 - S_1) = 3{,}270$.

Substituting above values for D' and $(S_0 - S')$ in Equation 35, we get for the transverse shear V, the following:—

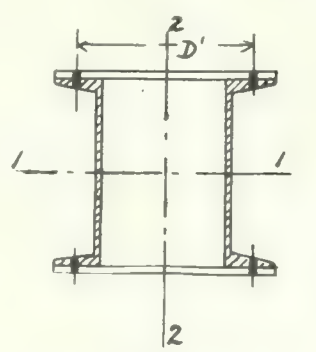


Fig. 10.

7" channel column 9' 0" long, $V = 6\frac{3}{4} \times 3{,}270 \times \frac{5.7}{2} \times \frac{22}{7} \times \frac{1}{108} = 1{,}830$ lbs.

According to tests, $V = 12,730 \times 5.7 \times .0251 = 1,820$ lbs.

10″ channel column 12′ 0″ long, $V = 9\frac{1}{4} \times 3,150 \times \frac{8.92}{2} \times \frac{22}{7} \times \frac{1}{144} = 2,830$ lbs.

According to tests, $V = 12,850 \times 8.92 \times .0251 = 2,877$ lbs.

12″ channel column 15′ 0″ long, $V = 11\frac{1}{4} \times 3,250 \times \frac{12.06}{2} \times \frac{22}{7} \times \frac{1}{180} = 3,850$ lbs.

According to tests, $V = 12,750 \times 12.06 \times .0251 = 3,859$ lbs.

15″ channel column 18′ 0″ long, $V = 13\frac{1}{4} \times 3,270 \times \frac{19.8}{2} \times \frac{22}{7} \times \frac{1}{216} = 6,240$ lbs.

According to tests, $V = 12,730 \times 19.8 \times .0251 = 6,320$ lbs.

Now, for a further demonstration, if we take the column that was actually tested,

$$\frac{l}{r} = 37.8,$$

$$l = 21' \, 0'',$$

$$D' = 16,$$

$$A = 18.76,$$

$$\frac{l^2}{r^2} = 1,429,$$

$$S' = 12,840,$$

$$(S_0 - S') = 3,160.$$

Then $V = 16 \times 3,160 \times \frac{18.76}{2} \times \frac{22}{7} \times \frac{1}{252} = 5,915$ lbs.

According to test, $V = 12,840 \times 18.76 \times .0251 = 6,046$ lbs.

Referring to the above, it seems to the writer that the formula given in Equation 35 for the transverse shear certainly agrees to a surprising degree with the figures for the transverse shear given in Bulletin No. 44, which gives ratio of transverse shear to compression load = .0251; and, as pointed out before, this was for a column having $\frac{l}{r} = 37.8$ and the slope of the lattice bars with axis of column = 63° — 30′.

It hardly seems reasonable that the above is only a coincident.

Now, to prove that Equation 27 and Equation 35 will give the same results:—

Equation 27 gives the stress in the end lattice bars when $\phi = 60°$.

Equation 35 gives the transverse shear and therefore must be multiplied by the sec of $(90° - \phi)$. This will give the stress in the end lattice bar, but as there are two lattice bars this result will have to be divided by 2.

For the angle referred to as ϕ see Fig. 9.

Take the 7″ channel column, 9′ 0″ long.

$$\operatorname{Sin} \pi \frac{x}{l} = .113.$$

$$(S_c - S_1) = 3,270.$$

$$\frac{A}{2} = 2.85.$$

Then, using Equation 27.

$b\,c = 3,270 \times 2.85 \times .113 = 1,053$ (stress in end lattice bar $b\,c$).

Using Equation 35.

$$V = 1,830.$$

Secant 30° = 1.155.

Then, stress in each end lattice bar $b\,c = \frac{1,830 \times 1.155}{2} = 1,056.$

If 15″ channel column 18′ 0″ is taken,

$$(S_c - S_1) = 3,270.$$

$$\frac{A}{2} = 9.9.$$

$$\operatorname{Sin} \pi \frac{x}{l} = .111.$$

Using Equation 27,

$$b\,c = 3,270 \times 9.9 \times .111 = 3,590.$$

Using Equation 35,

$$V = 6,240.$$

Then, stress in each end lattice bar $b\,c = \frac{6,240 \times 1.155}{2} = 3,600.$

Referring to Equation 20,

$$y = \Delta' \sin \frac{3}{2} \pi \frac{x}{l}. \quad \text{[Equation 20.]}$$

(Column fixed at top and round at bottom. See Fig. 7.)

$m = Py$, substitute for y.

Therefore $m = P\Delta' \sin \frac{3}{2} \pi \frac{x}{l}$

$$\frac{dm}{dx} = P\Delta' \frac{3\pi}{2l} \cos \frac{3}{2} \pi \frac{x}{l}. \quad \text{[Equation 36.]}$$

Substitute $D' (S_0 - S') \frac{A}{2}$ for $P\Delta'$, then

$$\frac{dm}{dx} = V = D' (S_c - S') \frac{A}{2}, \frac{3\pi}{2l} \cos \frac{3}{2} \pi \frac{x}{l}.$$

[Equation 37.]

Equation 37 gives the transverse shear at any point x when the top of the column is fixed and the bottom is round.

When $x = 0$, or $\frac{2}{3} l$ then Equation 37 becomes

$$V = D' (S_c - S') \frac{A}{2}, \frac{3\pi}{2l} \quad \text{[Equation 38.]}$$

Equation 38 gives the transverse shear at round end of the column (bottom) and at a distance of $\frac{2}{3}\,l$ from the bottom.

The shear at the top is zero, also at a point one-third up from the bottom.

Referring to Equation 22, Merriman gives $m = 2\frac{1}{4}$ when columns are fixed one end and round the other.

Substitute this value for m and values for S and E, then

$$S' = \frac{16,000}{1 - \frac{1}{13,000} \frac{l^2}{r^2}}. \quad \text{[Equation 39.]}$$

Referring to Equation 21,

$$y = \Delta'' \sin 2\pi \frac{x - \frac{l}{4}}{l}. \quad \text{[Equation 21.]}$$

Column fixed top and bottom. (See Fig. 8.)

$$m = P\Delta'' \sin 2\pi \left(\frac{x - \frac{l}{4}}{l} \right)$$

$$\frac{dm}{dx} = P\Delta'' \frac{2}{l} \cos \pi \left(\frac{4x - l}{2l} \right) \quad \text{[Equation 40.]}$$

Substitute $D' (S_0 - S') \frac{A}{2}$ for $P\Delta''$, then

$$\frac{dm}{dx} = V = D' (S_c - S') \frac{A\pi}{l} \cos \pi \left(\frac{4x - l}{2l} \right)$$

[Equation 41.]

Equation 41 gives the transverse shear at any point x when both ends of the column are fixed.

If $x = 0$, then $\left(\cos\pi\frac{4x-l}{2l}\right) = \cos 90 = 0$ and the end shear $V = 0$.

If $x = \frac{l}{4}$, then $\left(\cos\pi\frac{4x-l}{2l}\right) = \cos 0 = 1$, and the shear becomes

$$V = D'(S_0 - S')\frac{4\pi}{l}. \quad \text{[Equation 42.]}$$

Equation 42 gives the transverse shear at a distance $\frac{l}{4}$ from each end of the column, which is a maximum.

Referring to Equation 22,

$$m = 4.$$

Substitute this value for m, and values for S and E. Then,

$$S' = \frac{16{,}000}{1 + \frac{1}{23{,}200}\frac{l^2}{r^2}}. \quad \text{[Equation 43.]}$$

This value of S' to be substituted in Equation 42.

The value of the shears V, obtained in Equations 35, 38 and 42 should be multiplied by the secant of the angle ($90° - \phi$) and then divided by 2 to give the stress in the end lattice bars $b\,c$.

Reply to Mr. Goodrich.—Referring to Mr. C. M. Goodrich's discussion, would say that he was right in his criticism that A should be $\frac{A}{2}$, and I have corrected this above.

He mentions that the lattice bars are too wide at $2\frac{1}{4}''$ and suggests $1\frac{3}{4}''$ for the small columns. This, of course, is a matter of shop practice and depends a great deal upon the size of the rivet that is being used. He states that r is taken for the wrong axis. Upon looking up Cambria, and checking over the r used, I find that in a few places the value for r may be wrong, such as for $7''$ channel I took 2.34, and upon carrying the calculations out to the fourth place I find that this should be 2.38, but I am sure this would not affect the results materially.

He says that Mr. Pritchard suggests using 3% of the axial stress, and further on states that the new Quebec bridge lattice takes a shear of 2% of the axial stress, but he doesn't in any place state upon what authority 3% or 2% was taken, nor does he say whether he agrees with this assumption or not, or whether he thinks this value should be taken for all lengths of columns or how the columns should have their ends fixed when the above values are used.

If Mr. Goodrich believes there is a transverse shear equal to 2% of the axial load, then he must also believe there is bending in the column, for we know that

$$\frac{dm}{dx} = V,$$

where V is the vertical shear.

Or, in other words, when there is any possibility of the member acting in any way as a beam, it is not possible to have a shear without a moment except as dx approaches zero.

Therefore, if V is 2% of the load on the column (centrally loaded), it must necessarily follow that it must be a function of the bending of the column, even though the column be less than a ratio of $200\frac{l}{r}$.

Upon referring to the report of the Royal Commission, Quebec bridge inquiry, I find that Mr. Schneider has assumed that the column will bend into shape of a parabola due to eccentricities of load caused by fabrication, and he has given a formula for the transverse shear as follows:—

$$S_{max} = 8C\frac{ar}{d}.$$

Where $C = 70$, d = out to out of flanges; this then resolves itself into

$$S_{max} = \frac{280\,ar}{n},$$

$$\text{where } n = \frac{d}{2}.$$

This is the same equation as given in my first discussion for Equation (d). I also find that the particular member under discussion had a ratio of $\frac{l}{r} = 35$, approximately.

Reply to Mr. Harkness.—Referring to the discussion by Mr. A. H. Harkness, he has pointed out the same error as previously mentioned.

If you take my original Equation 11, which is

$$M = P\Delta\sin\pi\frac{x}{l},$$

and differentiate this, we get

$$dm = P\Delta\cos\pi\frac{x}{l}\cdot\frac{\pi\,dx}{l},$$

$$\text{or } \frac{dm}{dx} = P\Delta\frac{\pi}{l}\cdot\cos\pi\frac{x}{l},$$

which is the transverse shear on the column, and this equation is the same as Equation (2) given by Mr. Harkness. He has, then, substituted for $P\Delta$, the quantity

$$f\frac{Ar^2}{n}.$$

I think his analysis is a neat treatment of the subject, and, as he says, a quicker method of arriving at the result.

Reply to Mr. Molitor.—Mr. Molitor is of the opinion that, due to imperfections of fabrication, it would be impossible to get an exact formula for the stresses in lattice bars. I thoroughly agree with him, and pointed that fact out in my article, but I do think it possible to arrive at a formula that is based on theory and that will give reasonably safe results, and this was my object.

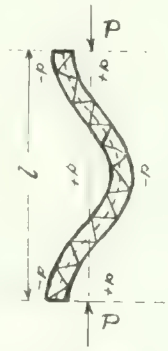


Fig. 8a.

Mr. Molitor derives the old formula,

$$R = \frac{280\,ar}{n},$$

but afterwards discards it, and states in his last paragraph the following:—

"These flanges being subject to compression from end to end, the function of the lacing and batten plates will be to transfer longitudinal shear *from one flange to the other* whenever and wherever the compressive stress is unequally distributed. The maximum value of this

shear may, under certain conditions, approach the total load P on the column and hence the total area of lacing and batten plates should be sufficient to carry the shear. This will serve as a good criterion in designing lattice columns and represents the writer's practice, though the whole subject is largely a matter of standards."

I would draw attention to Fig. 8a, which shows a column fixed top and bottom. It will be noticed that there is a compressive stress at the top and bottom, designated by $+ p$, and this, then, appears at the centre on the opposite side. Now, this stress $+ p$ is due to the bending of the column, and might, as Mr. Molitor says, approach the size of P if the deflection were great enough.

The stresses shown in Fig. 8a should fulfil Mr. Molitor's conditions excepting that one also gets a transverse shear as given by Equation 42. I do not quite see how Mr. Molitor could get a longitudinal shear without a transverse shear, and if the conditions that I suggest are right, then the longitudinal shear must be taken up by $\frac{l}{4}$, and not by the whole length of the column.

W. W. PEARSE,
City Architect and Supt. of Bldg.,
Toronto, Ont.

Toronto, April 27th, 1916.

COAST TO COAST

Petrolea, Ont.—Hydro power was turned on for street lighting and domestic use last week.

Toronto, Ont.—The hydraulic dredge "Cyclone" has started work on the Lake Shore Boulevard scheme.

Toronto, Ont.—The Trent Valley power bill, validating the purchase of the Seymour power interests, has been passed against strong Liberal opposition.

Edmonton, Alta.—The Legislature has made an important amendment to conserve the natural resources of the province. The export of natural gas has been prohibited.

Ojibway, Ont.—Official denial is given to reports which recently have been current to the effect that the United States Steel Corporation had abandoned its plans to erect a large new plant here.

Medicine Hat, Alta.—If the C.N.R. build their line here this year it is likely that the Saskatchewan Bridge and Iron Works will complete and operate their new plant. About 200 men will be employed.

Banff, Alta.—Considerable roadwork has been done in the Rockies by interned aliens. They have been constructing parts of the new automobile road which will ultimately run from Vancouver to Winnipeg.

Calgary, Alta.—The trouble between the C.P.R. and the farmers in the western irrigation block has been settled. An entirely new contract will be entered into by the settlers, of whom there are about 1,000 in the western block.

Edmonton, Alta.—A new hotel enterprise in the form of a tented city is to commence operations in the near future in Jasper Park. The government has built a network of good roads to points of interest in the park during the last year.

Port Moody, B.C.—The main building of the steel works is now completed and 26 car-loads of machinery is now on the ground while heaps of miscellaneous scrap iron and steel litters the ground in the immediate vicinity of the plant. About 50 men are employed.

Toronto, Ont.—The need of diverting Bloor Street to provide for the construction of a viaduct over the Humber River at some future date has been brought to the attention of the Board of Control by R. Home Smith. The matter has been referred to Works Commissioner Harris.

Montreal, Que.—The reason for the increase in the capitalization of the Nova Scotia Steel and Coal Company, which was authorized at the annual meeting a few weeks ago, is now becoming apparent. It is now believed that the company will soon embark upon the steel shipbuilding industry.

Montreal, P.Q.—The Canadian Research Bureau has been established by the Canadian Pacific Railway. Its purpose is to investigate and study the natural resources of the country in a scientific manner. Research laboratories will be established at different points in the Dominion.

Victoria, B.C.—According to Jos. J. Warren, president of the Kettle Valley Railroad, the line from Nelson to the coast will not be put in operation until July 1st. The delay has been caused, it is said, by the heavy snow in the interior. Only 1½ miles of line remain to be completed.

Peterborough, Ont.—The township of North Monaghan is doing roadwork on broader and more extensive lines this spring than it has attempted heretofore. The work for the most part consists of rebuilding and repairing gravel roads. A new road drag has been purchased by the authorities.

Toronto, Ont.—Dr. T. Kennard Thomson has outlined a scheme for a new power development at Niagara Falls. Dr. Thomson's scheme is to build a dam several miles below the Falls and thus preserve the natural beauties of the district, the water being used after it passes over the Falls.

Victoria, B.C.—The Provincial Government is considering a project for the development of the water power possibilities of the province on a large scale, according to an announcement by Hon. Lorne Campbell, Minister of Finance, who was the guest of honor at the annual meeting of the Victoria Board of Trade.

Welland, Ont.—At a joint meeting of the Council and the Hydro-Electric Power Commission a statement was made that the consumption of hydro power had reached 73,000 horse-power. This, it is said, is the greatest amount owned by any municipality in Ontario. The plant has showed a surplus ever since the first year of operation.

The Pas, Man.—Steel laying on the Hudson Bay Railway will be resumed on May 1st from mileage 242. The steel cantilever bridge at this mileage has been completed and trains will be operated over it shortly. There is a demand for railway laborers and 1,000 men are required to carry on the season's construction programme.

Winnipeg, Man.—The waters of the Red River have been in flood and damage amounting to thousands of dollars has been done. Sewers have been undermined and pavements have collapsed. Many buildings have been damaged by their cellars being flooded and foundations weakened. The railways operating out of here have had great difficulty in keeping their lines open.

VANCOUVER BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

E. G. Matheson, M.Can.Soc.C.E., gave his postponed lecture on "Pneumatic Foundations" on April 13th last.

Editorial

ACCELERATED PAVEMENT TESTS.

Accelerated pavement tests are receiving the attention of a great many highway engineers and chemists, and it is quite likely that in a few years some method will be invented which will enable the engineer to ascertain to a greater degree of certainty, before be builds a pavement, just how long that pavement will last.

In a recent lecture at Columbia University, C. N. Forrest, chief chemist of the Barber Asphalt Paving Co., said that a series of tests which could be applied to the pavement in place would be more satisfying to the engineer than the type of tests now employed.

Admittedly this is true; but the suggestion seemed so far in advance of any practical methods that are available at the present time, that *The Canadian Engineer* inquired of Mr. Forrest whether he had any idea as to how such a series of tests could be made.

Mr. Forrest replies that he cannot figure out any test such as he suggests would be desirable if someone could kindly invent it. An interesting point in Mr. Forrest's reply, however, is that the design of physical tests, for laboratory use, upon the equivalent of the pavement in place, *i.e.*, compressed test specimens of the composition or mixture as a whole, is now fairly well worked out for sand and fine stone aggregates.

These tests, applied at extremes of temperature, indicate the relative value of different proportions of raw materials, so that the best combination thereof can be adopted as a standard for the entire work in which they are to be used. They also indicate the relative value of various proportions of any asphalt when considered in connection with the mineral aggregate that is available.

It is possible to determine the degree of plasticity of the mixture, *i.e.*, its capacity to resist pushing and its resistance to wear by attrition. Having selected the materials for the work, and the best proportions, the chief consideration in this test scheme, in getting the mixture in place in the street, is proper compression. A measure of compression is the specific gravity of a sample taken from the pavement after compression.

Chemical analysis of the mixture, penetration of the asphalt cement, etc., will serve for plant control, says Mr. Forrest. If such a plan of operation is sufficient for the purpose, then any failure in the street later on would probably be due to workmanship or to engineering details such as drainage or strength of concrete base.

SEWAGE DISPOSAL PLANTS NEEDED.

The city of Lethbridge, which has been suffering from an epidemic of typhoid fever this spring, has presented a memorial to the premier of Alberta asking that the government compel towns to construct sewage disposal systems. According to Dr. Jamieson, the provincial bacteriologist, who has been investigating conditions at Lethbridge, the cause of the epidemic there is due to a polluted water supply. The city of Lethbridge procures its water from the Old Man River, and it is chlorinated. It would seem, however, that the degree of chlorination has not been sufficient to prevent the present epidemic. Doubtless under normal conditions the amount of chlorine used would have been ample, but under conditions such as are alleged to have existed, it was insufficient.

Dr. Jamieson carefully examined all probable sources of infection. The milk supply naturally was among the first of the city's organizations to come under suspicion; but here no fault could be found. All the dairies serving the city were found to be free from bacteria. The water supply was the sole source of trouble. Water samples which had been sent to Edmonton several weeks before the epidemic broke out had been pronounced potable. Evidently, then, the water had been polluted in the interim. Old Man River and its tributary watershed were investigated. It was found that the town of Macleod had had an epidemic of typhoid during the months of October and November last year, and that they were dumping raw sewage into the river. Spring freshets washed downstream all the impurities that had been deposited during the winter.

It is only fair that all towns discharging sewage into streams that are used as sources of water supply should treat their sewage before doing so. If a town will not take precaution to safeguard the health of its neighbors by looking after its own disposal of sewage, then such measures as are suggested in the memorial prepared by the city of Lethbridge, are most certainly needed.

LETTER TO THE EDITOR.

Stresses in Concrete Arch Dams.

Sir,—Mr. W. Gore's remarks in *The Canadian Engineer* of March 30th, 1916, regarding the desirability of relying upon "initial stress" to assist the stability of a concrete arch dam have been carefully read. The writer takes pleasure in attempting to answer the questions, especially because it is evident that Mr. Gore has given the subject considerable study.

Suppose the "initial stress" does not assist the stability of such an arch dam, and this it does not in arch dams carelessly constructed, then more load would be thrown on the cantilever, some more load taken up by shear action in the lower portion of the dam along the foundation, and some additional load thrown on the arch towards the crest. On a high, slender section this condition may cause higher cantilever stresses than desired; that is, high compression at the toe.

Fortunately, however, full load is not thrown on such structures in an instant, but weeks or perhaps months are generally required to fill up the reservoir. During this interval the modulus of elasticity of the concrete has had time to adjust itself according to the different amount of stress thrown on different portions. Due to the action of the time factor (for concrete only), parts highly stressed such as the toe, deforms much more than in proportion to the load carried, and, of course, as the concrete yields, more load is transferred to some other place of lower stress, thereby relieving the most highly stressed part. That is one reason why Formula 8, page 321, is empirical. For the benefit of anyone interested in the action of the

time factor upon stress and deformation, the writer wishes to refer to two papers read at the Twelfth Annual Convention of the American Concrete Institute in Chicago, February, 1916. One by Mr. Earl B. Smith, entitled "Concrete Flows Under Sustained Load," abstracted in The Engineering Record of March 4th, 1916. The other paper, entitled "Tests Showing Continued Deformation Under Constant Load," By Prof. A. H. Fuller and Prof. C. C. More, University of Washington, Seattle, Wash.

For carefully constructed dams the writer feels that the theory holds true. High, massive arches should be provided with contraction joints, say, 50 feet apart (on small dams these are not necessary as the section is more flexible), and the structure built up in alternate sections between contraction joints, the closing being effected during cold weather. The dam should not be built too fast, 20% plum stones should be used if practical. In addition, on important work, the contraction joints should be provided with grout pipes to facilitate the grouting of these joints under pressure during cold weather with reservoir empty after having been full at least once.

Such a dam structure is likely to follow the theory in its action; it is very likely to be absolutely watertight, and, of course, safe, if designed for reasonable stresses, say, less than 30 tons per square foot. According to the writer's view, careful construction is more important than the use of low stresses in the design. The concrete used should have a crushing strength of approximately 1,200 lbs. per square inch when 28 days old.

The writer wishes to point out the possibility of constructing an arch dam in such a manner that the stresses are actually better distributed than Formula 10, page 322, would indicate. This can be accomplished by using many plum stones in the concrete along the upstream face, and few or none along the downstream face, thereby making the shrinkage due to setting less along the upstream face, and also making the modulus of elasticity higher along this face, both of these conditions tending to effect a transfer of stresses from the downstream face towards the upstream face, and also tending to lessen the cantilever stresses at the downstream toe, making all stresses more uniformly distributed than the formulas would indicate they are.

LARS JORGENSEN.

San Francisco, Cal., April 11th, 1916.

OBITUARY.

COLIN McLEAN, one of the best-known contractors on the Atlantic seaboard, died at his home in Baltimore recently of pneumonia. He was born in Nova Scotia seventy-two years ago. Among his undertakings were the construction of the foundations for the Statue of Liberty and Brooklyn Bridge.

Dr. WILLIAM FREDERICK KING, chief astronomer of Canada and commissioner for the survey and marking of international boundaries, died on April 23, at the observatory residence, Ottawa, Ont. The late Dr. King was born at Stowmarket, Suffolk, England, 62 years ago, coming to Canada with his parents eight years later. He entered the service of the Dominion Government in 1872 as assistant astronomer on the North American Boundary Commission, and became inspector of surveys for the Dominion in 1881. He was made chief inspector of surveys in 1886 and chief astronomer of the Department of the Interior in 1890.

PERSONAL.

J. H. McMILLAN, of Cumberland, has been appointed inspector of mines with headquarters at Prince Rupert, B.C.

H. D. CAMERON has been appointed mechanical engineer of the Canadian Northern Railway, with office at Toronto, Ont.

JOHN AHEARN has been appointed superintendent of the Ottawa Street Railway. Mr. Ahearn has been with the company for 15 years.

A. J. RANDALL, formerly manager of the Saskatoon Iron Works, Saskatoon, Sask., has gone to Winnipeg, where he will take an officer's course.

G. V. HASTINGS has been appointed by the Winnipeg city council to succeed J. H. ASHDOWN as one of the commissioners on the Winnipeg and St. Boniface Harbor Board.

W. H. DINSMORE has been appointed traffic superintendent of the Vancouver city and suburban lines of the British Columbia Electric Railway, succeeding Mr. James Hilton, resigned.

FREDERICK KEFFER, mining engineer, Spokane, Wash., has left for Ashcroft, B.C., where he will take charge of constructing a concentrator for copper ores of the Highland Valley Company.

E. D. W. COURTICE, assistant superintendent of the John Street pumping station, city of Toronto, has resigned his position to enter the employ of the Hare Engineering Company, Limited, as assistant engineer.

R. S. LEA, M.Can.Soc.C.E., Montreal, has been in attendance at the session of the International Waterways Commission, Washington. Mr. Lea reported to the Commission on the level of the Lake of the Woods, Manitoba.

ARTHUR D. LITTLE will have charge of the new Canadian Research Bureau which is being established by the C.P.R. Mr. Little is a past president of the American Chemical Society and a member of the Institute of Chemical Engineers.

G. H. STEVENS has resigned his position as electrician-in-charge of the Fort Erie district for the Canadian Niagara Power Company, and commenced his duties as power apparatus specialist, Northern Electric Company, Montreal, on April 1st.

R. P. TRIMBLE, mining engineer, Portland, Ore., has returned from a trip to California and is leaving immediately for Telkwa, B.C., to commence development and take charge of operations at the Cassiar Crown Copper Company's property.

WILLIAM G. MURDOCH, city engineer of St. John, N.B., addressed the engineering students of the University of New Brunswick recently on the Suspension Bridge. His address was very instructive and much appreciated by the engineers.

Lieut. N. H. DANIEL, B.A.Sc., who left with the Divisional Cyclists Corps as a private and was later granted a commission in the Tenth Motor Machine Gun Battery, has been wounded. Lieut. Daniel is a graduate of S.P.S., Toronto, and was a member of the rugby team in his final year.

BLAIR RIPLEY, M.Can.Soc.C.E., who has had charge of C.P.R. grade separation in Toronto, has been appointed to command a new construction battalion with the rank of Lieutenant-Colonel. The battalion will be composed of men engaged in bridge building, railway construction, roadwork and general construction for overseas service.

Volume 30. Toronto, May 11, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

THE ROLLING AND FLOATING STEEL CAISSONS OF THE LEVIS DRY DOCK AT LAUZON, P.Q.*

PART II.

A DETAILED DESCRIPTION OF THE DESIGN, FABRICATION AND ERECTION OF THE FLOATING CAISSON.

By LESSLIE R. THOMSON, B.A.Sc., A.M.Can.Soc.C.E., Assoc.M.Am.Soc.C.E.,
Engineering Staff, Dominion Bridge Co.

IN a previous article the rolling caisson and its intricacies were described; in this, the floating caisson, while radically different from the rolling gate, will probably be found to lend itself more readily to an easy and understandable description.

The floating caisson of this dock is a large structure designed to be floated to and then swung across the berth entrance, sunk with its bearing pieces against the sills, subsequently, when berth is emptied, to act as a dam against the sea water, and to afford passageway from one wall to the other. It must consequently possess four distinct characteristics: (1) It must be able to float when desired. (2) It must be capable of being submerged at will. (3) It must be strong enough when acting as a stop gate to carry the tremendous hydrostatic loads and transmit them to the sills. (4) While in position it must provide a passageway for light traffic.

The caisson in general outline is shown in Fig. 1. It will be noted that the keel section is straight, likewise the stems, which are, however, flared so that the overall length at elevation of bridge deck is 133 feet 6 inches. The depth of the structure is 50 feet. The cross-section shows clearly the arrangement of the chambers and decks, which are named as follows: Keel, ballast chamber, deck E, air chamber, deck D, tidal chamber, deck B, motor and floor stand space, and deck A (traffic deck).

The ability of the caisson to successfully float or submerge itself as required by (1) and (2) will be discussed fully later.

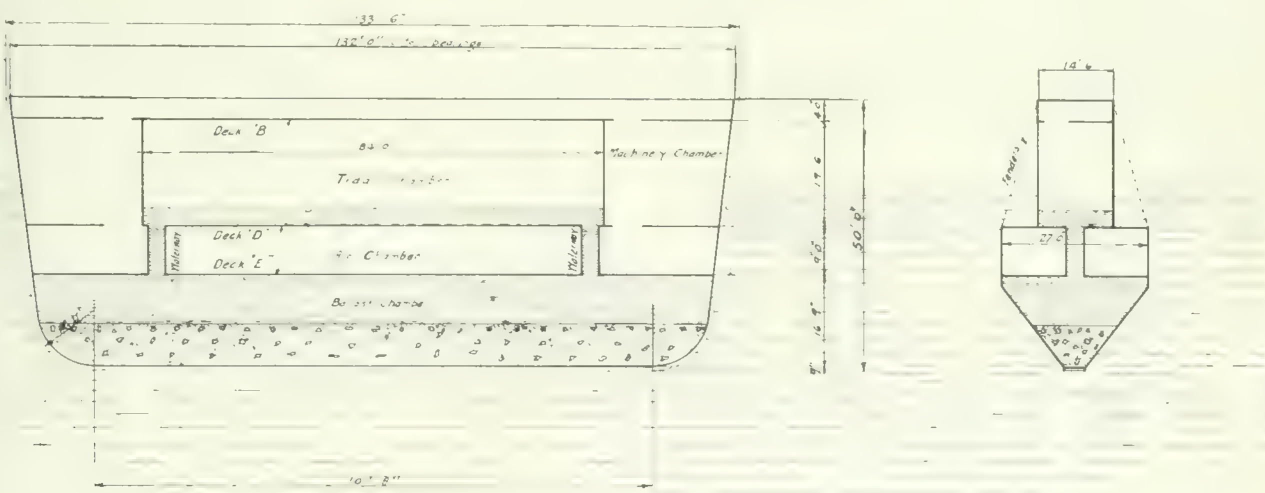


Fig. 1.—Line Diagram of the Floating Caisson.

None of the mechanical equipment of the caisson is shown in Fig. 1, which is only intended to illustrate the general outline of the gate and the arrangement of its decks and chambers, consequently there is no indication given of even the six large 42-inch filling culverts which run completely through the caisson, and through whose agency the berth is flooded when desired.

At the very bottom of the structure is seen the concrete ballast, enough of which is placed to enable the minimum draft of caisson (no water ballast whatever) to be 22 feet 6 inches, thus giving 2 feet 6 inches clear over sills at low water, mean spring tides.

It will be next noted that the tidal chamber does not run the full length of the caisson, but is only about 84

*Extract of part of paper read before a meeting of the Mechanical Section of the Canadian Society of Civil Engineers at Montreal, March [illegible], 1916.

feet long, leaving a large air space at each end. These spaces are used as machinery chambers, and in them are placed the motors, valves, valve controls, drains, etc., necessary to either float or submerge the gate.

It will be noted that the two ends are tapered to meet the stem pieces—in a somewhat similar way to a ship's bow, but the lines are not at all easy, being straight and rather blunt. This was done, of course, to aid the fabrication of the gate, as very few bridge companies have facilities to handle a large amount of curved plate work—so easily accomplished in a modern ship yard.

Passing now to the top, there is installed within a watertight box, a 15-h.p., d.c. motor used to drive a long horizontal countershaft from which are actuated, through floor stands, the various main valve stems. The motor is controlled from the outside of its box by an extended controller shaft, and it will be at once seen that the operation is practically identical with that of the rolling caisson.

Above the valve-operating devices is located the traffic bridge provided with folding rails. At the ends of this bridge cantilever brackets are used to support its corners enabling the bridge to terminate with its clear width. In order that the gate may swing in to its berth under all

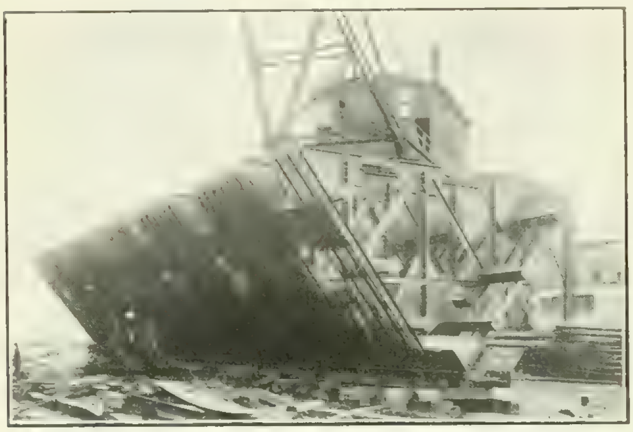


Fig. 2.

variations of tide, the masonry coping has been moulded to the necessary clearance.

The structural design of many parts of this caisson presented certain features rarely encountered, but before going into any detail, a short resumé of the general design may not be out of place. As in the rolling caisson, the department had proposed a general scheme upon which bidders were asked to tender, with the clear understanding that a certain amount of latitude to suit their own particular fabricating requirements would be given. Messrs. M. P. and J. T. Davis, the successful tenderers, submitted a fairly general design of their own; and this design was accepted, after a few changes had been agreed upon, in order to satisfy the requirements of the department of public works. The most important of these changes was the substitution of flared stems instead of vertical ones. On this amended layout the Dominion Bridge Co. then tendered to Messrs. M. P. & J. T. Davis, and on accepting the tender Messrs. Davis required the Dominion Bridge Co. to check all stresses and sections. During the course of this work certain changes were recommended, chief among which may be mentioned the increase of the width of keel and stems from 18 inches to 4 feet. This point will be touched upon a little later.

As in the rolling caisson, the main stress unit required by specification was 12,000 lbs. per square inch; and these specifications also required that the whole gate should be reversible.

The hydrostatic loading against the caisson when acting as a gate was assumed to be triangular with a depth of 46.25 feet, making a unit stress at the bottom of 2,885 lbs. per square foot.

This loading is, of course, applied directly to the skin plates which in turn deliver it to the frames of which there are two kinds—"strong frames" and "light frames"—corresponding to the ribs in ordinary ship construction. The light frames, placed at 1-foot 9-inch centres, pick up their portion of the skin load and deliver it through longitudinal pieces to the strong frames, which load the main

Fig. 3.

horizontal plate girders constituting decks E, D and B. The distribution of the actual loads to these respective girders was accomplished in an exactly similar manner to that used in figuring the loading of the trusses of the rolling caisson, illustrated in Fig. 1 of the article on the rolling caisson. On this basis, then, the loading to deck B is 4,260 lbs. per lineal foot; to deck D, 14,760 lbs. per lineal foot; to deck E, 25,680 lbs. per lineal foot, and the keel sill, 21,900 lbs. per lineal foot.

The design of the stems afforded one of the most interesting features of the whole gate. The reactions of the girders are as follows: B, 281,000 lbs; D, 930,000 lbs.; E, 1,590,000 lbs., and it is the duty of the stem girder to distribute these high concentrations over as much of the

sill area as possible. The necessity for this will be evident after a glance at the following figures. If, for example, the reaction of deck E be delivered over an area of 15 inches x 15 inches (the space immediately under its own bearing pieces) the resulting load on the oak is approximately 7,100 lbs. per square inch. This is evidently the worst case, namely, that in which the stem is not distri-

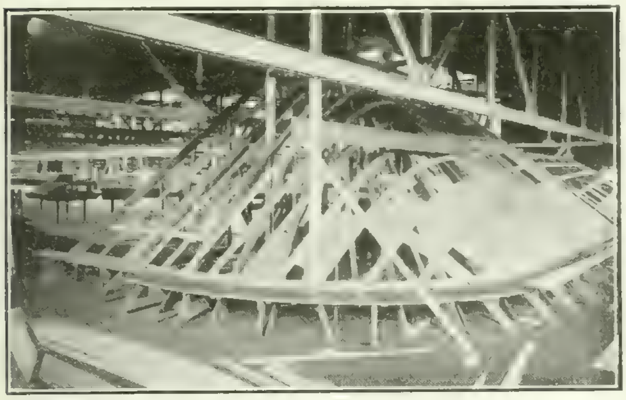


Fig. 4.

buting the reactions at all. On the other hand, suppose the stem distributes the load uniformly over 13.13 feet (equals ½ of 9 feet + ½ of 17.25) giving a load on the oak of 840 lbs. per square inch. It is apparent that even under these ideal conditions the load is very heavy and hence the importance of the stem is realized. In passing, it may be noted that the oak bearing pieces are enclosed by steel angles.

The keel was designed to be quite similar to the stems with, however, several changes due to the distinct differences in the duties of the two members. The function of the stem was to receive two highly concentrated loads and distribute them over as large an area as possible. The duty of the keel is, however, to receive and transmit directly to the sills a uniformly distributed load. Hence it is apparent that no bending moment will be developed within the keel, nor will there be any extremely heavy concentrations. It was, therefore, possible to reduce the flange material very markedly and also to dispense with the necessity of bearing between webs and flange plates. All stiffeners, both inner and outer, were accurately fitted by milling to bear against the flange angles, and these became excellent paths for the load distribution. Breast hooks were also supplied at every weak frame, *viz.*, at 1-foot 9-inch centres. These breast hooks are clearly seen in Fig. 2, taken during the yard assembly.

Additional stiffness for the tidal chamber portion is gained by the presence of the heavy diagonal fenders which are stiffened half-way up by 24-inch gussets.

These fenders, besides aiding in a very effective way the sway bracing system, are necessary to preserve the exposed portions of the deck against injury from falling bodies of any kind. They are shod throughout their whole length with 12-inch x 12-inch white oak, which serves as a buffer against contact with berth walls should any local disturbance cause violent rocking of the caisson when floating. Wooden strips are also inserted in the chords of decks E and D. These are 12 inches x 12 inches and, naturally, run completely around the caisson, and act as buffers against injury during those times that the gate is floating beside one of the dock walls.

The bearing strips of this caisson are all white oak. The thickness of these varies from point to point along the stem and keel, depending on the number of flange and splice plates inserted. In addition to these oak bearing strips there are buffer strips to absorb the shock as caisson is settling on to the bottom or oscillating against berth walls. Owing to the lay-out of the keel and stems, the axis of this caisson during contact with masonry may be quite oblique with no danger of steel touching masonry.

The structural design of the rest of the caisson followed along usual lines, and offers no field for any extended comment.

The layout, however, of the traffic bridge possesses certain points of interest that may with advantage be briefly described. As mentioned previously, the floor stands are situated on deck B, which is about 4 feet below the bridge. Consequently, over each floor stand a hatch had to be provided, and each hatchway is large enough to allow space for a checkered plate stairway from the steps of which the attendant may operate the floor stand mechanism. These hatches are well over to one side of the bridge.

In addition to the floor stand hatches there are five others—two main hatches, two ladderway hatches leading to the tidal chamber, and one motor box hatch. The main hatches lead directly into the machinery chambers and are large enough to admit the passage of any of the pieces of mechanical equipment. In order that a motor and pump might not have to be disturbed to give passage, for example, to a 42-inch valve being removed for repairs, the hatchway was offset from the centre line of the motor by about 4 feet 6 inches. It is through these main hatches, also, that the scuttling valves are operated. The ladderway hatches merely give direct access to the tidal chamber, and the remaining hatch to the watertight motor box and controller handles.

The fabrication of the steelwork of the floating caisson presented several problems only met with at very infrequent intervals by a bridge company. Especially was this the case in regard to the ends of the structure, which are similar to ships' bows.

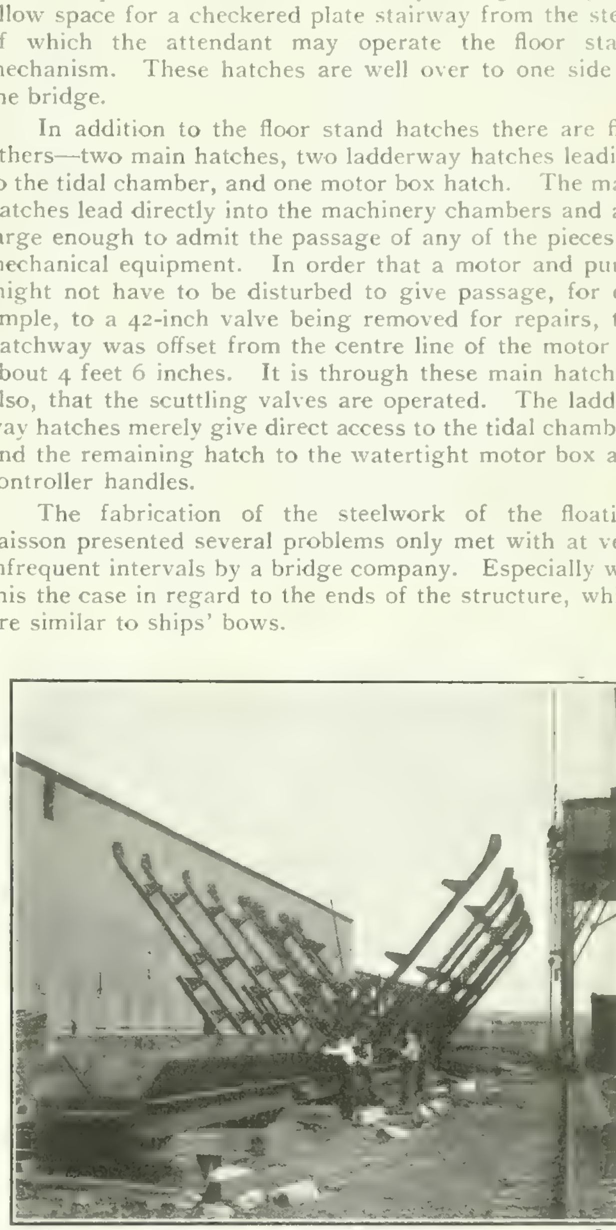


Fig. 5.

In order to simplify as much as possible the lay-out and detailing of these curved portions, an accurate wood and cardboard scale model of one-half of one end was constructed. This was made by the template shop shortly after the main design features were settled; and the scale selected was 1½ inches to the foot. Fig. 3 shows this model very distinctly. The name sheet is fastened to the

wall of the air chamber (5550 being the contract number of the work), while the sheet of plain paper above is on the wall of the machinery chamber.

The photograph of the model shows clearly a number of interesting points which may be named without further

Fig. 6.

comment—shape of skin plates, amount of skin plate included in the shop riveting of the stem portions, the retention of vertical frames throughout (the blacksmith shop taking care of the bent and warped work introduced), the position of the breast hooks, and one of the filling culverts.

The plates were detailed as completely as possible. In certain of the more difficult portions of the bent work the drawing office developed the plates and showed the general position of all rivets, but left the exact location of them to the template makers. In order to insure that the work would go together without loss of time or material, it was decided to assemble the templates in the shop before sending them out, and Fig. 4 shows this assembly. It will be noted that the caisson is, as it were, lying on its side.

As an additional precaution, it was decided to assemble in the yard the whole lower portion of the floating caisson, and the accompanying photographs clearly show the progress of the work. Attention might be called to the immense size of the gate, necessitating its yard assembly by the largest travelling crane in the possession of the Dominion Bridge Co.

The caisson, in order to carry out the service required of it, must be capable of submerging itself, becoming buoyant, and when acting as a gate it must allow ballast water inside to rise and fall freely with all changes of the tide. To submerge the caisson, valves are located in each stem; these admit water until the degree of submergence desired is reached. To become buoyant, two pumping units installed in the machinery chambers at each end of the caisson pump the water out until the caisson floats. Each unit consists of one 100 h.p., 2-hour rating, 1,150 r.p.m., 550 volts, vertical d.c. motor, direct connected to an 18-inch axial flow, Mather & Platt centrifugal pump. The capacity of the pump at about 1,200 r.p.m. is 5,000 gallons per minute against a head of 40 feet.

When it is desired to close the berth the caisson will be pulled across the entrance and fitted to the keel and stem blocks. This will usually be done at low tide. If not, and there is no need for haste to close the berth, the tide will be allowed to fall to its lowest point before any submerging is done. An operator will then go to the swinging valve levers and pull them from vertical position to the horizontal. The caisson will immediately commence to flood its ballast chamber and will naturally begin to settle. As soon as the keel is resting evenly on its keel bed, the bridge ends will then necessarily be in their proper position, and the gate is therefore able to provide a communicating bridge for traffic between the two sides of the berth. The berth is then emptied in the usual way and the gradually increasing pressure against the gate tends to seal it more and more securely against the sills. The rising tide flowing freely through the main flooding valves gradually will fill the whole ballast chamber and thence will find its way through the two waterways to the tidal chamber. This process will be automatic as no attention need be given the valves once they are opened.

When it is desired to flood the berth, the valve motor is started and an operator then engages in succession the clutches that actuate the valve stems of the six 42-inch diameter valves. These admit enough water to quickly flood the berth.

When the elevation of the water on each side of the gate is the same, the two flooding valves are closed by swinging up the control levers. This prevents the entry of any more ballast water. The two centrifugal pumps are then started and the caisson will be gradually emptied of its ballast which will, of course, enable it to float. Once it becomes buoyant it may be towed away from the berth entrance and placed where desired.

The free play of the tide within the caisson is accomplished by the main flooding valves, and the importance

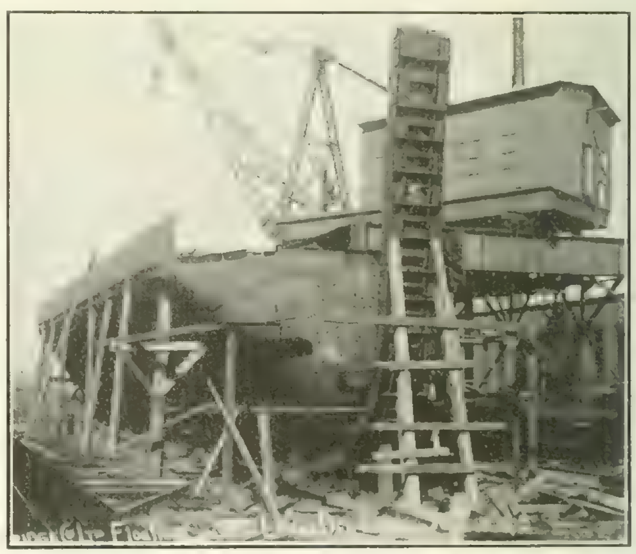


Fig. 7.

of this unrestricted movement of the ballast water cannot be overestimated. The reason for this statement is readily seen when it is realized that the caisson, when berthed, must have increased water ballast for each rise of the tide;

otherwise the incoming tide would tend to lift it vertically, and slide it along the sills. Should this ever happen, it would mean heavy wreckage and probable loss of life within the berth, due to the sudden inrush of water. The only way to prevent this is to allow an increasing amount of water ballast within the structure as the tide rises and thus insure its stability against the hydrostatic uplift. The thing to guard against was, therefore, the closing of the main flooding valve when the caisson is submerged and acting as a stop gate. This point was felt to be so important that it was decided to make the control of the flooding valve of such a nature that it would be humanly impossible to have it closed when circumstances would demand its being open. It will be remembered that when the caisson is berthed it is designed to act as a crossing between the two sides of the dock, there being a communicating bridge on the top. Consequently, if its roadway were artificially obstructed until the main valves were in the open and safe position, it was agreed that there would be small danger of the valves being left closed through inadvertance. The visual effect of a large notice board blocking the roadway, which could only be put out of the way by leaving open the main flooding valves, was thought to be a surer guarantee of safety than any attempted interlocking device between valve stems.

The erection of the floating caisson was carried on simultaneously with that of the rolling, the arrangement effecting a great economy in the use of the derrick car.

The heavy keel section was placed on a series of wedged keel blocks placed approximately at 3 feet centre to centre. These were carefully lined up and adjusted so that the keel came to an absolutely true bearing. The frames were then assembled up to elevation of deck E. From this point on no particular difficulty was encountered.

Messrs. M. P. and J. T. Davis, with Mr. S. H. Woodard as chief engineer, are the general contractors for the whole dry dock project; and all the work in connection with these two steel caissons was given to the Dominion Bridge Company, Limited, Montreal, as subcontractors. Of this company Mr. G. H. Duggan is general manager; Mr. F. P. Shearwood, assistant chief engineer; Mr. A. E. Johnson, mechanical engineer, Mr. P. L. Pratley, designing engineer and Mr. D. C. Tennant, chief draftsman, while to the writer was entrusted the direct charge of the work from its early stages. Changes in design were only made after consultation with the Department of Public Works, Ottawa, represented by Mr. U. Valiquet, supervising engineer, and Mr. S. J. Fortin, structural engineer. They had also the approval of all detail drawings.

By the beginning of September, 1915, without reckoning roads constructed in the region occupied by the field army, work had already begun on the construction of a network of Russian State railways with a length of 3,530 miles, to cost $315,368,000. The construction has been sanctioned of new lines totalling 300 miles at a cost of $26,478,000, and the building was proposed of new railways totalling 1,812 miles, at an outlay of $196,194,000. In all, these new lines and branches have a length of 5,645 miles, and for their construction is demanded about $538,000,000. The realization, however, of proposals for the building of new lines has been postponed till the end of the war.

At Drammen, Norway, new zinc works are about to be started for the extraction of zinc by an electric wet process, invented by a Belgian engineer, M. Sturbelle. Raw materials for the first year, about 10,000 tons, have been secured, and special attention will be paid to ores containing from 8 to 30 per cent. zinc, which have hitherto been considered as really worthless.

SOME SUGGESTIONS PERTAINING TO THE OPERATION OF WATERWORKS PLANTS.*

By John W. Toyne.

THE operation of a waterworks plant is essentially a question of management, and in the present paper I have treated it exclusively from this viewpoint.

The management of any utility consists of two distinct features—the management of the physical plant through the utility's operating force and the management of the utility's business relations with its customers. This is equally true whether the utility is privately or municipally owned. Applicable, too, to both, are the several regulations recently adopted by the public service commissions in Indiana as well as other States.

The management of the physical features of a utility is an engineering problem, and I use the term "engineering" in its broader sense, which includes experience, sound judgment and the ability to build and maintain a loyal organization, as well as the essential theories taught us in the technical schools. Any one of these alone is good; all are absolutely essential in order to attain the most desirable results, and as in any line of endeavor really worth while there is no "royal road" to real success.

The questions that continually confront the manager of a utility are: Of what does my plant consist? What is its value? Of what is it capable? Is it rendering the highest possible efficiency? Is it rendering the best service possible? What provisions must be made to meet changing conditions? Is anything being overlooked that is essential? Does it pay?

I am afraid if we were asked these or similar questions a great many of us, at least, would experience some little difficulty in assuring even ourselves that we really knew the answer.

Is it sufficient, from the standpoint of the manager, to sum up one's plant as so many acres of land, so many buildings, certain pumping machinery, so much power generating equipment, so many miles of distribution pipe lines, so many hydrants, valves, meters, etc., enumerating only the physical items? Does not the human element, the operating force, enter as largely into the make-up of a plant as its mere physical properties?

Given the best equipment, the most scientifically designed distribution system and an unfailing supply of water, and still your plant is sadly deficient if this feature has not been properly provided.

A knowledge of the value of the plant, not only in its entirety but by units, is essential in order that provisions may be made for replacements as well as a fair return above maintenance during their useful life. In my own work I have adopted the system of permanent, unit inventory, showing for each unit, wherever possible, date of purchase, manufacture, purchase price, cost of installation, probable life, depreciation annuity and present value. In a great many cases the compilation of an inventory of this character is a really formidable undertaking, owing to the incomplete and inaccurate data of record necessary, but once developed it is of inestimable value to the manager, even though frequent corrections or adjustments must of necessity be made.

Every manager cannot only well afford but cannot afford not to paraphrase Pope into "Know, then, thy plant"; not only its value, either its cost or appraised unit

*Read at annual convention of the Indiana Sanitary and Water Supply Association.

value, but its capabilities, the utmost duty that can be derived from each unit, the percentage load that will render the highest efficiency, taking into consideration the interest charge on the investment, the depreciation accruing and the continual advance being made toward more perfectly efficient machinery by the manufacturers. This can be determined only by actual tests intelligently conducted; and the results, to be of value, must be so compiled as to be available for comparison with performance data in operation, as only in this way can the operation be brought to even approximate the ideal.

The standard by which everything must be measured is the service rendered; this applies not only to the service rendered by the plant to the utility, but by the utility to its customers. The service rendered the utility by its plant is governed entirely by the manager; by his ability to know his plant, to build and maintain an organization loyal to him and his aims, to derive the highest efficiency possible from his plant, to anticipate the demands of changing conditions and make the necessary provisions.

The determination of the value of the physical plant, together with the point of highest operating efficiency of each unit, represents but a small portion of the manager's work in securing the best possible service from his plant.

The work of building and maintaining a loyal organization is fully as important and requires infinitely more ability, judgment and application. It is, in fact, the test of the real manager, as the service rendered the utility by its plant is entirely dependent on this element. Personally, I have had no success with any form of organization having more than one head. This applies not only to the utility as a whole, but to each department and bureau, and in this connection one must always remember responsibility fixed cannot exceed the authority granted. To me, a bureau, department or utility with more than one head, a job with more than one boss, is as ridiculous as a two-headed hen.

In building his organization the manager must know the results desired, the qualifications necessary to get the results, and must be able to judge human values with this in view, otherwise he cannot hope to have a well-balanced, efficient organization. The manager's work is not completed with the building of his organization. To be of real value it must be maintained. It has none of the attributes of perpetual motion other than the constant expense. Its maintenance requires a world of tact, infinite patience, and, above all, absolute fairness, with a real knowledge of his physical plant, its value and possibilities with an operating force properly organized and thoroughly loyal; the service that can be commanded from its plant by a utility is limited only by the ideal.

The service rendered its customers by a utility is equally dependent on the manager for the attitude of his operating force will be largely a reflection of his own. He must always bear in mind that his customers have a right to expect prompt service cheerfully rendered, as well as courteous attention at all times. Absolute fairness is as imperative in the manager's dealings with the customers of the utility as with his operating force, as in no other way can he build up a real "good will" asset.

Standards of service are being established by the several public service commissions. A great many of those prescribed have been exceeded for years by a number of the utilities. Others will, I believe, work a real hardship on the utilities without materially adding to the service rendered the customers of the utility.

Every manager is continually confronted with changing conditions, not only as it affects the physical plant but in the service requirements, the increase in population served, the extended area covered by his distribution, changes in direction of the city's growth; all these intimately affect the utility and must be anticipated by the manager if he would avoid serious embarrassment in serving his customers.

If a manager really knows his plant as outlined he will not only be in a position to know, but will know whether it pays, and how well.

In my own work I have found that a slight change in the method of firing saved tons of coal in generating steam; that apparently slight changes in piping prevent unnecessary waste of energy; that a careful routine saves hours of unnecessary labor in reading meters and delivering bills; that a division of the city into payment districts, while in no way reducing the service to the consumer, saves the utility approximately a thousand dollars per year in office labor.

In the item of permanent records of his plant, a manager can, through careful selection or development of forms and accuracy in their use, save much unnecessary labor and render better service. I have found card systems and loose leaf records more flexible and, consequently, more readily adapted to the requirements of a utility.

To sum up, the manager must be all things to his utility and his customers. He must always be in touch with his plant, with his operating force, with his customers and with his field of work in general, as no utility can exist for itself alone. There is a constant advance in equipment, methods and service, and only by keeping fully abreast can any manager hope to render the best service to his utility, its customers and himself.

RAILWAY EARNINGS.

The following are the railroad earnings for the first three weeks of April:—

Canadian Pacific Railway.

	1916.	1915.	
April 7	$2,482,000	$1,766,000	+ $716,000
April 14	2,577,000	1,701,000	+ 876,000
April 21	2,343,000	1,623,000	+ 720,000

Grand Trunk Railway.

April 7	$1,155,486	$1,008,320	+ $147,166
April 14	1,024,505	864,658	+ 159,847
April 21	1,059,661	869,772	+ 189,889

Canadian Northern Railway.

April 7	$ 677,000	$ 457,000	+ $220,000
April 14	668,900	463,700	+ 205,200
April 21	634,000	442,300	+ 192,000

The Canadian Northern Railway's figures for March are as follow:—

	1916.	1915.	
Gross earnings	$2,607,000	$1,898,500	+ $708,500
Expenses	2,240,600	1,397,700	+ 842,900
Net earnings	366,400	500,800	— 134,400
Mileage in operation	8,270	7,181	+ 1,089

The company states that the decrease in net earnings compared with last year is due to snow blockades and other interruptions to movement of traffic, which increased operating expenses abnormally.

The March comparative figures of the Canadian Pacific Railway are as follow:—

	1916.	1915.	Inc.
Gross	$10,380,981	$7,852,989	$2,527,992
Expenditure	6,959,651	4,879,074	2,079,676
Net	$3,421,330	$2,973,914	$ 448,316

REVIEW OF 1915 PAVING WORK

ANNUAL REPORTS OF CITY AND TOWN ENGINEERS THROUGHOUT CANADA SHOW THAT THEY ARE DOING "BUSINESS AS USUAL"—SUMMARY OF TOTAL AMOUNT OF PERMANENT PAVEMENTS NOW LAID IN SOME OF THE CANADIAN CITIES.

"BUSINESS as usual" appeared to be the slogan of most of the Canadian cities and towns during 1915, at least so far as paving work was concerned. True, in some cases a falling off in work was evidenced, but, on the other hand, many of the towns did more work in 1915 than in 1914.

Of special interest is the report of the six largest cities in the Dominion. Toronto spent $1,327,108 on new pavements, which was $100,000 more than was spent in 1914. Montreal spent $1,388,967 in 1915. The exact figures for 1914 for Montreal were not reported, but it is stated that the 1915 expenditures compare very favorably with 1914. Hamilton spent only $46,000 less than in 1914. On the other hand, Winnipeg carried out but very little of its 1915 programme, doing nothing that was comparable to the 18 miles of pavement that were laid in that city in 1914; and Vancouver constructed absolutely no new pavements whatever in 1915, confining their entire attention to repair and maintenance. At a cost of $470,040, Ottawa laid 139,068 yards in 1915, as compared with 177,712 yards in 1914.

Table I. shows details of the new paving done in 1915 by a half dozen of the leading Canadian cities. It is somewhat of interest to note that of the 1,639,808 yards laid by Montreal, Toronto, Winnipeg, Ottawa and Hamilton, 86.9% was sheet asphalt or other bituminous pavement, 5.3% brick, 4.5% stone block, 1.6% concrete, 1.0% wood block and 0.7% macadams other than bituminous. The 10,621 sq. yds. of "other macadams" laid in Toronto was chiefly Rocmac; the 200 sq. yds. in Winnipeg was water-bound macadam. 26,808 yards of the stone block laid by Montreal was granite. The stone block laid in Winnipeg was for subway approaches. Most of the bituminous macadam laid by these six cities in 1915 was Tarvia.

Table II. shows the total yardage of permanent pavements as at January 1, 1916. If the 350,000 sq. yds. of water-bound macadam in Toronto and the 5,300,000 sq. yds. in Montreal are not counted, Toronto has by far the largest amount of permanent pavements of any city in Canada. But if the water-bound macadam is counted, Montreal leads by a substantial margin. It is quite probable, however, that those 5,300,000 yards in Montreal represent streets that will sooner or later gradually be replaced with more permanent types.

No untreated wood block was laid in these cities in 1915, but they have 348,222 yards of untreated wood block laid previously.

8,658 yards of the concrete pavement in Toronto are surfaced with Dolarway. The Vancouver figures for concrete in Table II. include some Granitoid.

Most of these six cities have not yet made up their 1916 paving program, as in many cases the extent of the work depends upon the petitions made by the property owners. To date, however, Ottawa has decided upon an expenditure of about $350,000 and Montreal $981,419.

Paul E. Mercier is chief engineer of Montreal. R. C. Harris is commissioner of works for Toronto and M. A. Stewart, assistant city engineer in charge of paving. The city engineer of Winnipeg is W. P. Brereton. F. C. Askwith is acting city engineer of Ottawa, and Andrew F. Macallum is city engineer of Hamilton. F. L. Fellowes is supervising city engineer of Vancouver.

The figures given in this article probably do not represent more than 10% of the paving work that was done in Canada during 1915, yet it is interesting to note what work even a small portion of the towns and cities are doing. We are, therefore, quoting the following figures from the annual reports of some of the city and town engineers:—

Amherst, N.S.—J. E. Parker, city engineer. Spent $45,000 in 1915 for 17,000 sq. yds. of concrete. Total pavements laid to date in Amherst are: 28,800 yds. concrete and 20,000 yds. asphaltic concrete.

Berlin, Ont.—Herbert Johnston, city engineer. Spent $56,033 in 1915 for 21,323 yds. bituminous macadam and 3,061 yds. concrete. Total pavements laid to date are: Asphaltic concrete, 60,459 yds.; concrete, 3,661 yds.; creosoted wood block, 10,740 yds.; bituminous macadam, 6.43 miles; gravel and water-bound macadam, 24.22 miles. It is estimated that about 6,050 sq. yds. of concrete are to be laid in 1916, and a little bituminous macadam.

Calgary, Alta.—Geo. W. Craig, city engineer. Spent $31,760 in 1915 for 12,294 yds. asphaltic concrete and 405 yds. stone block. Total pavements laid to date: Asphaltic concrete, 1,030,176 yds.; brick, 745 yds.; stone block, 14,155 yds.; creosoted wood block, 100,132 yds.; Granitoid, 95,651 yds.

Dunnville, Ont.—S. Shupe, town engineer. Spent $12,500 in 1915 for 5,690 yds. bituminous macadam. Only other paving in town is 11,833 yds. of concrete previously laid.

Edmonton, Alta.—A. W. Haddow, city engineer. Spent $138,000 in 1915 for 4,810 yds. concrete, 27,020 yds. asphaltic concrete and 1,867 yds. sheet asphalt. Total laid to date: Sheet asphalt, 187,175 yds.; asphaltic concrete, 633,197 yds.; concrete, 37,000 yds.; creosoted wood block, 35,947 yds. The 1916 program calls for an expenditure of about $185,000.

Fort William, Ont.—Ray Knight, city engineer. Spent $13,464 in 1915 for 10,916 yds. water-bound macadam. Total to date: Sheet asphalt, 14,613 yds.; asphalt, block, 47,383 yds.; asphaltic concrete, 65,264 yds.; water-bound macadam, 56,117 yds.; Rocmac, 24,523 yds.; gravel, 25.51 miles.

London, Ont.—H. A. Brazier, city engineer. Spent $166,793 in 1915 for 63,517 yds. asphaltic concrete, 2,655 yds. brick, 5,022 yds. concrete, 6,397 yds. gravel. Totals: Asphalt block, 4,242 yds.; asphaltic concrete, 173,754 yds.; brick, 23,520 yds.; concrete, 14,882 yds; gravel, 89,760 yds; and some water-bound macadam. It is estimated that about $150,000 will be spent in 1916, possibly for 60,000 yds. asphaltic concrete, 3,200 yds. brick, 5,000 yds. concrete and 4,500 yds. gravel.

Moose Jaw, Sask.—Geo. D. Mackie, city engineer; W. H. Greene, assistant city engineer. Totals: Sheet asphalt, 6,197 yds.; brick, 5,050 yds.; creosoted wood block, 107,447 yds.

Niagara Falls, Ont.—W. C. Jepson, city engineer. Spent $20,600 in 1915 for 3,340 yds. brick, 3,280 yds. concrete and 5,000 yds. water-bound macadam. Totals: Brick, 22,300 yds.; concrete, 8,600 yds.; water-bound macadam, 207,000 yds.; Westrumite, 6,200 yds.; Glutrin, 4,500 yds.

North Bay, Ont.—H. J. McAuslan, town engineer. Spent $24,414 in 1915 for 31,834 yds. water-bound macadam. Totals: 74,000 yds. water-bound macadam.

Oak Bay, B.C.—R. Fowler, municipal engineer. Laid 13,728 yds. Tarvia in 1915. Totals: Sheet asphalt, 49,000 yds.; water-bound macadam, 42,000 yds.; Tarvia, 109,800 yds.; tar-sprayed macadam, 160,000 yds. Expect to lay 15,250 yds. Tarvia in 1916.

Peterborough, Ont.—R. H. Parsons, city engineer. In 1915 laid 41,102 yds. asphaltic concrete. Totals: Asphaltic concrete, 79,823 yds.; concrete, 975 yds.

Regina, Sask.—L. A. Thornton, city commissioner; D. A. R. McCannel, acting city engineer. Totals: Sheet asphalt, 174,239 yds.; asphalt block, 54,314 yds.; concrete, 31,987 yds.; stone block, 4,682 yds.; creosoted wood block, 47,648 yds.; bitulithic, 276,242 yds.

St. Hyacinthe, Que.—Hector Cadieux, city engineer. Spent $22,000 in 1915 for 10,000 yds. asphaltic concrete and 1,000 yds. bituminous macadam. Totals: Asphaltic concrete, 10,000 yds.; water-bound macadam, 20,000 yds.; bituminous macadam, 1,000 yds.; other macadams, 1,800 yds. It is estimated that about $50,000 will be spent in 1916, which will include probably 30,000 yds. of tar or asphaltic macadam.

St. Lambert, Que.—E. Drinkwater, town engineer. Spent $165,231 in 1915 for 58,411 yds. bitulithic and 406 yds. Scoria block. Totals: Sheet asphalt, 20,049 yds.; bitulithic, 64,412 yds.; water-bound macadam, 3,863 yds. in good condition; asphaltic macadam, 7,100 yds.; Scoria block, 406 yds. 1916 paving will include some bitulithic.

Stratford, Ont.—A. B. Manson, city engineer. Spent $31,450 in 1915 for 16,632 yds. bituminous macadam. Totals: Asphalt block, 30,954 yds.; brick, 30,287 yds.; concrete, 6,404 yds.; bituminous macadam, 53,151 yds.; Westrumite, 40,643 yds.

Sydney, N.S.—B. M. McKinnon, acting city engineer. Spent $34,019 in 1915 for 16,720 yds. Tarvia. Will probably lay 24,000 yds. Tarvia in 1916 at a cost of about $48,000.

Welland, Ont.—D. T. Black, city engineer. Figures for 1915 paving not given. Totals to date: Brick, 49,000 yds.; water-bound macadam, 10,000 yds.; creosoted wood block, 6,100 yds. Among the 1916 paving will be 7,000 yds. of concrete or 3-inch Tarvia X on concrete base.

Westmount, Que.—P. E. Jarman, city engineer. Spent $41,171 in 1915 for 6,826 yds. sheet asphalt, 9,355 yds. of concrete and 933 yds. of asphaltic macadam. Totals: Sheet asphalt, 126,566 yds.; bitulithic, 2,953 yds.; concrete, 18,720 yds.; water-bound macadam, 53,715 yds.; asphaltic macadam, 168,784 yds.; other macadams, 3,700 yds.; stone block, 37,392 yds. Of the 1916 paving work only $21,700 has been authorized as yet.

As stated before, the figures given above probably do not represent more than 10% of the paving done in Canada in 1915, as figures are given for only one-third of the cities and towns which had over 7,500 population at the time of the last Federal census; and, moreover, these figures do not include interurban highways, such as the Toronto-Hamilton Highway, etc., nor the smaller municipalities, such as Montreal South, Longueuil, etc., each of which probably spent from $2,000 to $25,000 on paving work in 1915. Nor do they include the amount spent by the Federal government, by the nine provinces, by the 154 counties, or by the western districts. For instance, Peel County, Ont., spent $21,462 in 1915 for 6,000 yds. gravel, 15,000 yds. water-bound macadam and 20,000 yds. bituminous macadam; and has voted $52,000 for roads and bridges for 1916, of which about $20,000 will be spent for 20,000 yds. gravel, 25,000 yds. water-bound macadam, and 10,000 yds. tar or asphaltic macadam. As another instance of county expenditures, it might be cited that the expenditures in 1915 by the Ontario counties which were reported to the Provincial Government for subsidy claims, amounted to about $800,000. The amounts that will be spent in 1916, according to the reports of the county engineers to W. A. McLean, deputy minister of public works of Ontario, will be $800,000 on new construction and $200,000 on maintenance. It should also be noted that the above figures are not meant to include track allowance paving.

TABLE I.—PAVING DONE IN 1915 BY THE SIX LARGEST CANADIAN CITIES.

1915 Paving.* Square Yards.	Sheet Asphalt.	Asphaltic Concrete.	Bituminous Macadam.	Other Macadams.	†Brick.	†Concrete.	Stone Block.	Wood Block.	*Total Yardage.	1915 Paving Expense.*
Montreal	387,229	73,967	354,839	——	41,363	——	53,775	——	911,173	$1,388,967
Toronto	300,877	74,870	——	10,621	45,319	24,739	——	5,544	461,970	1,327,108
Winnipeg	18,388	——	——	200	——	1,018	2,558		22,164	57,311‡
Vancouver	——	——	——	—	-	——	——	——	——	Nil
Ottawa	94,418	——	19,240		-	——	17,310	8,100	139,068	470,040
Hamilton	89,707	11,374	——	——	385	1,200	——	2,077	105,433	197,400
Totals	890,619	160,211	374,079	10,821	87,067	27,047	73,643	16,321	1,639,808	$3,440,826

*Exclusive of maintenance and repair work and of track allowance paving and some gutters. †Exclusive of gutters built of this material. ‡Does not include cost of the stone block pavement in Winnipeg.

TABLE II.—TOTAL YARDAGE OF PAVEMENTS IN THE SIX LARGEST CANADIAN CITIES.

Total Paving.* Square Yards.	Sheet Asphalt.	Asphaltic Concrete.	Bituminous Macadam.	Other Macadams.	†Brick.	†Concrete.	Stone Block.	Wood Block.	Asphalt Block.	*Total Yardage.
Montreal ...	1,208,990	167,510	441,716	5,300,000	619,957	262,082	53,775	3,455	20,333	8,167,818
Toronto ...	3,373,148	805,087	50,000	410,162	580,520	158,658	84,053	64,457	92,707	5,079,458
Winnipeg ..	1,019,527	180,512	2,092	428,380	——	59,084	21,354	210,488	——	2,831,037
Vancouver.	143,088	493,152	19,008		41,184	53,592	73,128	727,320	—	1,550,472
Ottawa	772,417	4,600	136,035		——	—	7,083	35,742		955,877
Hamilton ...	658,975	85,466			37,177	2,728	1,541	116,650		902,543
Totals..	8,166,145	1,805,927	649,451	6,138,542	1,278,844	536,744	240,934	1,158,118	113,100	20,087,805

*To January 1st, 1916, exclusive of maintenance and repair work and of track allowance paving and some gutters. †Exclusive of gutters built of this material. Vancouver figures were compiled exactly in mileage but not in yardage. Figures here given are approximate. They were calculated upon an average width of 15 yards, as the Vancouver pavement widths vary from 30 ft. to 62 ft.

ROAD AND BRIDGE CONSTRUCTION AND MAINTENANCE IN THE PROVINCE OF NOVA SCOTIA.*

THE Province of Nova Scotia during the past year has expended on roads and bridges some $610,093. Of this total amount about 48 per cent. was for bridges and culverts of permanent construction and 38 per cent. for road maintenance, but this latter also included bridge painting and repairs. After deducting the amount used for bridge maintenance and dividing the remainder (about $167,500) among the 18,000 miles of highway in Nova Scotia the cost of maintaining a mile of road is found to be $9.19.

Road machinery is coming more and more into use each year, and if the demand for more road graders can be taken as an index of their popularity, they are coming more and more into favor, for the demand seems to be increasing. In some of the most rocky and difficult parts of the province the road grader is used very successfully, in other parts, on account of the small farms, it is difficult to get suitable teams for the work. In such places it is hard to get work done economically, as the teams have to be brought from outside districts. Even at this disadvantage, however, the grader proves more economical than any other method.

It is quite impossible from any reports or data furnished by the municipal councils to determine with any degree of satisfaction or accuracy either the nominal or real value of statute labor applied to the roads in the different municipalities. The returns submitted are far from complete. Based on the assessed value of property, there ought to be approximately $225,000, either in cash or commuted labor, or partly in one and partly in the other, so applied in addition to the annual appropriation made by the province. If this substantial item were made available in cash, it alone would average about $12.50 per mile. For obvious reasons there are very many sections throughout the province in which the full benefit of this provision for the maintenance of roads is not made available, or is so indifferently applied that the roads to which it should be applied derive little or no benefit therefrom. It must be apparent that if the full value of this statute labor could be effectively applied each year the results would be far more satisfactory and far more beneficial to the general condition of the roads of the province.

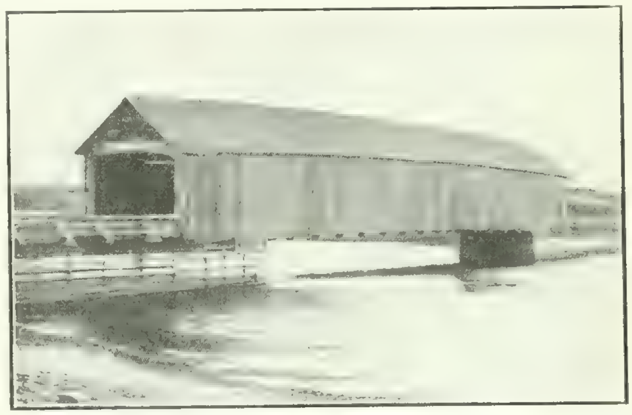
The estimate of 18,000 miles of highway in the province may give an erroneous idea of the condition of these highways. It must not be inferred that these 18,000 miles of highway are completed highways. It must be recognized that the greater part of the road mileage thus given is not improved road, in that it has never been properly ditched, shaped and drained, and often has not even good wooden culverts.

Were the roads throughout the province all properly drained, graded and shaped, with proper culverts, so that all the money provided annually could be expended in maintenance, a fairly good showing could be made. An earth road requires very frequent attention with both the road drag and the road grader if it is to be kept in good condition. At the same time, if the necessary frequent attention is given, earth roads can be kept in smooth condition and fit in every way for such traffic as the average road in Nova Scotia has to carry. A macadam road will cost annually for maintenance from $250 to $350 per mile, including a sinking fund, depending on the width of the metalled portion, and also on the location of the road and the character of the metalling.

The cost of maintaining a good earth road would be from $10 to $50 per mile annually, the cost depending very largely on the nature of the earth composing the prism of the road, earth of a gravelly nature being much less expensive to maintain than the soils in which there is a large portion of clay.

If the maintenance costs given above are correct, and they have been taken from statistics gathered from other places, principally in the United States, where extensive schemes of road work have been carried out, it will be seen that the sum, annually spent per mile in Nova Scotia by the Legislature, is not more than sufficient for the maintenance of the existing mileage of roads.

The installation of culverts and work done under various Acts has done much to improve the condition of the roads in the different counties, and the roads so improved, although they will still require a sum for maintenance, will not need the same amount of annual expenditure as in former years. Where road expenditures have been made out of capital on roads in which permanent culverts have been built, the improvements are,



Horton Covered Bridge over Cornwallis River. A fine type of Wooden Truss still doing good service.

of course, most marked, but even where culverts only have been installed, the ditching done to make the culverts effective has benefited the roads vastly, and the expenditure for maintenance out of revenue should be very much lessened.

The question of road maintenance in Nova Scotia is still a matter of the greatest importance, and one to which close attention must be constantly given, not only for future betterment, but to protect those highways upon which expenditures have already been made. As soon as the construction of a road has been completed, it is necessary that its maintenance should begin. Too often this has not been the case. On the contrary, after a considerable expenditure has been made upon a section of road, the idea seems to prevail that any maintenance is not necessary for some time. This is a mistake. After the construction of a piece of road is completed it will go to pieces in less than half the time it could be expected to last unless proper care is given it annually by way of maintenance. The policy of "A stitch in time saves nine" is most applicable to the maintenance of earth roads in this province.

If a new piece of road after construction is left absolutely without care, and the attention of the roadmaster

*Abstracted from the report of the Highways Division

is directed to some new section of road to be constructed, the result of this neglect is only what must be expected. In a short time small defects begin to appear, which readily grow serious, and if the neglect continues, it may be only a short time before the road surface goes entirely to pieces and the road begins to be a source of complaint. If the neglect still continues, criticisms of

Clarence Road. A Finished Macadam Road.

the original construction begin to be heard, and the majority of those interested come to believe that the fault is with the original method of construction rather than with the real cause, neglect.

The common way of performing road maintenance work is to get together a gang of men and teams and start out, either before the time for farming work begins in the spring, or after the harvest in the fall, and to attempt to do all the work for the year at one time, and that time a very short period. For the balance of the year the roads receive no attention at all, and the repairs, if any, are intermittent and irregular instead of constant, regular and careful.

There can be no question but that the same system of constant care over the roadbed of the highway as is adopted by railroads is the most economical that can be adopted in highway work. As a general thing, the construction and maintenance work of the railroads of this country has been performed efficiently and economically, and it is, therefore, reasonable to assume that the constant and careful maintenance of railroad tracks and other properties is considered by the railroad simply as good business, and that their judgment in the matter is worth respecting.

If, instead of intermittent and irregular repairs it were possible to substitute a definite scheme of maintenance, the results, without doubt, would show much improvement in the condition of the highways which are being cared for. An ideal system would be to have a patrol system, which would provide for the permanent employment of skilled laborers or caretakers, well accustomed to road work and repair. Each one of these patrolmen would have charge of a particular section of highway. The patrol system, of course, would not be applicable to all districts. Although the patrol system has been used to some extent as a means of upkeep for the roads in Nova Scotia, yet so far it has not been applied as extensively as could be wished. It is thought, however, that this system can be extended much further with great benefit to the roads.

Serious injury is done to many of the highways of the province by the use of narrow tires on heavily-loaded vehicles. The injury to the roads occasioned by the continued use of narrow tires on heavily-loaded vehicles requires annually the expenditure of a large amount of money to repair the highways on which they are used. This seems most unnecessary. Those who use them no doubt fully appreciate the importance and economic value of good roads for transportation. Nevertheless, evidence is furnished every year to indicate that this continual abuse of the roads will be made with apparent disregard of the serious consequences and the heavy charge upon the maintenance fund.

The Nova Scotia Farmers' Association recently sent a resolution to the legislature as regards the use of narrow tires. This is a move in the right direction, and the principle of this resolution is most heartily commended to the consideration of all those who are using, or rather abusing, some of our highways as above indicated. The benefit to the highways by the use of broad tires can hardly be over-estimated, and the cause of good roads will be much advanced when a proper recognition in some form or other is given to the recommendations of the members of the Farmers' Association.

The work done under the Act to Provide for the Betterment of Highways has, in nearly every case, been performed by labor obtained in the locality in which the work was done. The great difficulty has been in procuring men to do the work except at times best adapted to suit their own convenience. In seed-time, or during haying or harvesting, it has been found impossible to secure workmen in many of the counties to work on the roads when there was anything left on the farm to be done. This has had a tendency to delay much of the work to a later time in the year. While a very considerable portion of the work could be done to advantage at almost any season of the year, it is evident that in many cases the performance of this work late in the season was a decided disadvantage.

The ideal system would be to have all such work done by specially trained gangs. This is being carried out in some countries where special work of this kind is undertaken. In some sections of Nova Scotia the farmers find themselves too busy to permit them to work upon the highways, and there is a growing disposition to justify the roadmaster in employing men who have

Conquerall Bridge over Petite Riviere. Three spurs, 16 ft. each, Concrete Slab.

the time and who can devote their attention to this, and become more trained in the work.

In all cases where road improvements were made under this Act, specifications were prepared in the Roads Office, covering the method of executing the work. The work done in many places has been of a very superior order, and is an object lesson to many who have seen,

or who have travelled over the stretch of road so improved. It has been impossible in all cases to surface the road after improvement with either gravel or stone, but it has been the aim in every case undertaken to provide permanent drainage as the first consideration, and then, if possible, to have all the structures made permanent and the road surfaced. The essential point in road construction, and one that is always insisted on, is that thorough drainage shall first be accomplished, and this has always to be done before other improvements are put on the roads.

The Superintendent of Highways has, in nearly all cases, first gone over the ground with the foreman to be in charge of the work, directing him personally as to the execution of the work to be done, and he has besides made inspections as frequently as his time and duties would permit.

The results of the expenditures made under this Act have been the improvement of many bad stretches of road, and, while the magnitude of the expenditures does not permit of very extensive work being done in any one locality, yet the improvements made are very marked.

Main Port Road. A section of Earth Road which is still in splendid condition after being improved two years ago.

If the expenditure under the provisions of this Act could be further extended it would result in a continuance of the betterments already effected. An expenditure of this character seems all the more necessary and defensible because the means available from the ordinary revenues at the disposal of the various inspectors are inadequate to satisfactorily and efficiently maintain the roads as they should be maintained and at the same time do any construction work worthy of the name.

The work done under this Act in the various counties and the nature of betterments effected should have, and, it is believed, will have, a distinct influence towards bringing about better road work in the various districts, as the work serves as an object lesson.

As before stated, the amount of money used for bridge maintenance and construction was 48 per cent. of the total expenditure. The expenditure for repairs to larger bridges has been largely for renewal of the floor system of the bridges, but other repairs have also been made in many places to the approaches. These latter, however, are, as a rule, of much less cost. Two of the largest bridges, where the traffic is heaviest, have been fitted with wooden block floors with creosoted planking and joists. The result so far seems to justify the expectations, which were entertained, that these floors would have much more lasting qualities than the untreated floors, and that, although the cost was much in excess of the single-plank floor, yet the longer life would result in very increased economy.

The system of block paving bridge floors has now been tried by the Department for some five years, and, from the experience gained, it is the intention to further apply this method of construction, at least on the larger bridges where the travel is heavy.

RECENT DEVELOPMENTS IN BITUMINOUS MACADAM AND BITUMINOUS CONCRETE PAVEMENTS.*

BEFORE proceeding with the discussion of the many improvements in the construction of bituminous macadam and bituminous concrete pavements which have been developed during the period from 1914 to 1916, it is advisable, in order to avoid misunderstandings, to quote the definitions of the two types of pavements as recommended by the Special Committee on "Materials for Road Construction" of the American Society of Civil Engineers.

"Bituminous Macadam Pavement.—One having a wearing course of macadam with the interstices filled by penetration methods with a bituminous binder."

"Bituminous Concrete Pavement.—One composed of stone, gravel, sand, shell or slag, or combinations thereof, and bituminous materials incorporated together by mixing methods."

General.—Certain developments which are common to both classes of bituminous pavements will be discussed prior to considering improvements which specifically refer to each of the several types.

Foundations.—There has been a general acknowledgment of the ultimate economy of constructing adequate foundations to support the amount and character of traffic which the several types of bituminous pavements are able to carry. In the case of bituminous macadam pavements, this development usually has been characterized by the construction of well-compacted and, in many cases, thoroughly filled broken stone foundations. In the case of bituminous concrete pavements, due to numerous failures which have occurred where this type of pavement has been built on old macadam or poorly constructed broken stone foundations, there has been a general tendency to advocate the use of cement-concrete foundations from four to six inches in thickness. It has generally been found that the cost of cement-concrete foundations does not exceed the cost of well-compacted and filled broken stone foundations of equivalent strength. Furthermore, the use of cement-concrete foundations renders repairs and renewals more satisfactory and much easier of accomplishment.

Non-bituminous Highway Materials.—There has been a general recognition since 1914 of the desirability of covering in specifications in more detail and with greater rigidity the physical properties of the aggregates to be employed and the sizes of the particles which compose such aggregates. For example, the 1914 Specifications of the American Society of Municipal Improvements covering bituminous macadam pavements state, with reference to the physical properties of the stone, that the rock employed must meet the following requirements:—

*Presented before the Third Canadian and International Good Roads Congress, Montreal, Canada, on March 10, 1916, by Arthur H. Blanchard, M.Can.Soc.C.E.

The broken stone shall be subjected to attrition tests and toughness tests conducted by the Engineer in accordance with methods adopted by the American Society for Testing Materials, August 15, 1908. The broken stone used for the construction of the first and second courses shall show a French coefficient of wear of not less than 7.0 and its toughness shall be not less than 6.0. The broken stone used for the construction of the third course and for the first and second applications of No. 1 broken stone shall show a French coefficient of wear of not less than 11.0 and its toughness shall not be less than 13.0."

The necessity for more carefully drawn specifications covering the sizes of the particles of which a given product of a stone-crushing and screening plant is composed is illustrated by the following mechanical analyses of two products obtained from the same plant, both of which products passed over a section of a rotary screen having circular holes of 1¼ inches and through a section of a rotary screen having circular holes 2¼ inches in diameter.

	Sample "A"	Sample "B"
Passing [illegible] inch screen	0.2	0.1
" ¼ " "	0.1	0.1
" ½ " "	0.4	1.1
" ¾ " "	2.2	12.6
" 1 " "	8.0	37.5
" 1¼ " "	29.1	40.9
" 1½ " "	27.1	7.7
" 2 " "	32.0	0.0
	100.0	100.0

It is hence obvious that for many forms of bituminous construction, in order to secure successful results, greater care must be used in the writing of specifications for products of broken stone. As an illustration of an improvement in specifications covering this detail, there is cited those adopted at the 1915 Convention of the American Society of Municipal Improvements covering broken stone to be used for the aggregate of one type of bituminous concrete pavement.

"Broken stone for the mineral aggregate of the wearing course shall consist of one product of a stone crushing and screening plant. It shall conform to the following mechanical analysis, using laboratory screens having circular openings: All of the broken stone shall pass a one and one-quarter (1¼) inch screen; not more than ten (10) per cent. nor less than one (1) per cent. shall be retained upon a one (1) inch screen; not more than ten (10) per cent. nor less than three (3) per cent. shall pass a one-quarter (¼) inch screen."

It is noted that in this form of specification an attempt is made to cover in the mechanical analysis only the limits of the smallest and largest particles. No attempt is made to secure a carefully graded aggregate but simply a product suitable for the type of pavement in question and uniform in character. For example, the following mechanical analyses show three products used in the successful construction of three different bituminous concrete pavements of the type mentioned.

	Sample "A"	Sample "B"	Sample "C"
Passing [illegible] inch screen	1.2	2.7	1.0
" ¼ " "	4.2	5.4	2.5
" ½ " "	34.7	45.0	30.8
" ¾ " "	40.6	35.1	34.2
" 1 " "	17.3	10.3	23.4
" 1¼ " "	2.0	1.5	8.1
	100.0	100.0	100.0

Bituminous Materials.—There has recently been considerable discussion pertaining to the advisability of the adoption of so-called "alternate type" specifications in preference to the so-called "blanket" specifications for bituminous materials. By alternate type specifications is meant a series of specifications, each of which covers the physical and chemical properties of the most desirable grade of a given type of bituminous cement for the purposes for which it is to be used. On the other hand, a blanket specification covers in one set of requirements, pertaining to physical and chemical properties, all the types of bituminous cement which are to be used in connection with the construction of a given kind of pavement. For example, in the case of specifications for asphalt cement for bituminous concrete pavements, it would be desirable under alternate type specifications to have not less than five sets of physical and chemical requirements, the limits for each requirement being as narrow as the several processes of manufacture would permit, while on the other hand a blanket specification would cover with a wider range of limits the same chemical and physical properties for the five types mentioned. As an illustration will be cited the limits in the cases of Specifications "A" to "E" inclusive under the alternate type specification method for specific gravity, and the penetration at 25° C. (77° F.).

	"A"	"B"	"C"	"D"	"E"
Specific gravity—	0.97—1.00	1.00—1.03	1.03—1.04	1.025—1.05	1.04—1.06
Penetration—	75—90	90—100	70—90	85—95	140—160

In the case of a blanket specification to cover the same grades of the several types, the limits for specific gravity would have to be 0.97 to 1.06 and the limits for penetration would be 70 to 160. The penetration test, for example, can only be of maximum value when applied to the grade of a specific type of bituminous cement which is most suitable for the type of pavement in question. In the case of the bituminous concrete pavement of the type mentioned, the proper penetration limits for a California asphalt lie between 70 and 90, while for a fluxed Bermudez asphalt to be used in exactly the same type of pavement and under the same conditions, the penetration limits should be between 140 and 160. It is evident that to attempt to cover the penetration limits for both materials in one specification is impracticable. In the first place, such limits as 70 to 160 are so wide as to insure but little uniformity in different lots of the same material, and in the second place, an entirely unsuitable material of one class could be supplied under the maximum or minimum test limits of the other class.

The proper use of alternate type specifications allows the contractor to bid to supply so many tons of bitumen which will comply with any one of the sets of requirements. It will be noted, therefore, that the contractor is in exactly the same position as in the case when he bids to supply any asphalt cement which will comply with the requirements of a blanket specification.

Guarantees.—There has been a general tendency to abandon the use of guarantees on bituminous pavements as it is believed that, with proper specifications and efficient supervision and inspection, guarantees are not necessary and that the requirement of a guarantee materially increases the prices bid on a given pavement. The subject of guarantees is too broad to discuss in this paper but it should be noted that under the title "The Economics of Guarantees of Pavements on State and Municipal Highways," it has been admirably treated by Mr. George C. Warren in a lecture in the Graduate Course in Highway Engineering at Columbia University, which lecture has been published under the auspices of the National Highways Association, Mr. Charles Henry Davis, president.

Bituminous Macadam Pavements.—In addition to the improvements noted above, the most notable recent de-

velopment in the construction of bituminous macadam pavements has been in connection with the compaction of the road metal and the distribution of the bituminous materials.

As a result of the numerous failures of bituminous macadam pavements which have occurred due to the improper rolling of wearing courses of road metal prior to the application of bituminous material, there has been a general recognition of the necessity for more thorough compaction of the road metal. This principle has been recognized by the Special Committee on "Materials for Road Construction" of the American Society of Civil Engineers in its 1915 report, the conclusion referred to reading as follows:—

"An important factor for successful results is the proper compaction by rolling of the road metal before the spreading of the bituminous material."

The above committee emphasizes another improvement which is aimed at the use, in some cases, of an excess amount of bituminous cement in this type of pavement. This conclusion is as follows:—

"Present indications are to the effect that the use of bituminous materials in quantities of more than 2½ gallons per square yard where the upper course of the macadam is to be 3 inches in thickness after compaction is inadvisable under the penetration method."

There has been a general recognition of the advisability of using properly designed distributors in connection with the application of bituminous materials in order to secure uniform distribution economically. Some specifications cover the requirements which a distributor must meet. For example, the 1914 Specifications of the American Society of Municipal Improvements contain the following paragraph pertaining to the pressure distributor:—

"The pressure distributor employed shall be so designed and operated as to distribute the bituminous materials specified uniformly under a pressure of not less than twenty (20) pounds nor more than seventy-five (75) pounds per square inch in the amount and between the limits of temperature specified. It shall be supplied with an accurate stationary thermometer in the tank containing the bituminous material and with an accurate pressure gauge so located as to be easily observed by the Engineer while walking beside the distributor. It shall be so operated that, at the termination of each run, the bituminous material will be at once shut off. It shall be so designed that the normal width of application shall be not less than six (6) feet and so that it will be possible on either side of the machine to apply widths of not more than two (2) feet. The distributor shall be provided with wheels having tires each of which shall not be less than eighteen (18) inches in width, the allowed maximum pressure per square inch of tire being dependent upon the following relationship between the aforesaid pressure and the diameter of the wheel: For a two (2) foot diameter wheel, two hundred and fifty (250) pounds shall be the maximum pressure per linear inch of width of tire per wheel, an additional pressure of twenty (20) pounds per inch being allowed for each additional three (3) inches in diameter."

This specification provides for a distributor by which it is practicable, under competent supervision, to secure uniform application of the bituminous material and allows the use of a pressure distributor without danger of rutting of the wearing course of broken stone by narrow tires carrying excessive weights.

Bituminous Concrete Pavements.—The improvements in the construction of bituminous concrete pavements to which attention should be called will be considered under the following classification of the three types into which bituminous concrete pavements generally may be divided. These types are designated as follows—

(*a*) A bituminous concrete pavement having a mineral aggregate composed of one product of a crushing and screening plant.

(*b*) A bituminous concrete pavement having a mineral aggregate composed of a certain number of parts by weight or volume of one product of a crushing and screening plant and a certain number of parts by weight or volume of fine mineral matter such as sand or stone screenings.

(*c*) A bituminous concrete pavement having a predetermined mechanically graded aggregate of broken stone or gravel, either alone or combined with fine mineral matter, such as sand or broken stone screenings.

Patents.—Unfortunately the present status of patent litigation has to be considered in connection with the discussion of the several types of bituminous concrete pavements. The majority of engineers and highway officials are interested in the types of bituminous concrete pavements which may be constructed without danger of litigation rather than in a prolonged discussion of the probabilities of successfully defending suits for infringement. There is ample evidence at hand that bituminous concrete pavements of type (*a*) may be constructed without danger of litigation proceedings provided that the mineral aggregate is of the general character heretofore mentioned in this paper under the section "General. Non-bituminous Highway Materials."

The history of litigation cases indicates that the construction of bituminous concrete pavements of type (*b*) on a large scale will in all probability lead to litigation. The same remarks apply to the construction of bituminous concrete pavements of type (*c*) except in the case of the so-called Topeka bituminous concrete pavement with an aggregate of the type specified either in the 1910 Topeka decree, or of the grading which was adopted at the 1915 Convention of the American Society of Municipal Improvements.

Type (*a*) Materials.—Practice has demonstrated that broken stone, because of the satisfactory mechanical bond secured, makes the most suitable aggregate for this class of bituminous concrete although pavements constructed with gravel have proved satisfactory for light traffic where great care has been taken in the selection of the gravel and in the construction of the pavement. The development of the character of materials used in current practice has been covered in this paper under the title "General." Much more care has been taken in recent years with reference to the quantity of bituminous cement to be used in the mix. There has been a general recognition that the amount used depends upon the kind of road metal and the bituminous material, the character of the aggregate and the climatic conditions. For the product of broken stone heretofore mentioned, it has been found that bituminous concrete mixtures should contain between 5 and 8 per cent. by weight of bitumen.

Mixing.—Many improvements are noted in the methods employed in the mixing of bituminous concretes. There has been a general evolution from hand-mixing methods to the utilization of mechanical mixers especially designed for the manufacture of this type of bituminous concrete. The large contract for thirty-five miles of bituminous concrete pavement of this type around the Ashokan Reservoir, constructed under the direction of the Board of Water Supply of the City of New York, demonstrated the desirability of the manufacture of a plant especially designed for this class of work. The type finally evolved showed that it is practicable and economical to use a self-propelled plant, consisting of elevators, a rotary dryer, weighing devices and a mixer, having a capacity of from 800 to 1,000 square yards of 2-inch wearing course per day. Experience has demonstrated that, except on small contracts and for repair work, mixers which provide for

the heating of broken stone by the use of a flame in the chamber should not be used on account of the danger of burning the broken stone or the bituminous concrete.

Laying.—There has been considerable discussion pertaining to the proper type and weight of roller to be used for the compaction of the wearing course. Experience demonstrates that in order to secure an even surface and adequate compaction by thorough interlocking of the particles of broken stone, a tandem roller weighing between 10 and 12 tons should be used.

Seal Coat.—Many methods have been developed for the application of the seal coat of bituminous material. It has been found that seal coats of from ½ to 1 gallon per square yard of bituminous cement are distributed most uniformly by the use of hand-drawn gravity distributors followed by a squeegee.

Seasonal Limitations.—Experience in many localities has demonstrated that bituminous concrete of this type should not be mixed or laid when the air temperature in the shade is below 50° F. as otherwise it is difficult, under average conditions, to secure an even and well-compacted wearing course.

Type (*b*).—Specifications for this type of pavement have, during recent years, generally stipulated that so many parts of broken stone and so many parts of sand or other fine material are to be mixed with a certain amount of bituminous cement. By the use of this specification, unless employed under unusual supervision, it has been found to be impracticable to secure a well graded aggregate. In many cases the mixture has contained an excess of broken stone with insufficient fine material to fill the voids therein, while in other cases it has contained an excess of sand in which the broken stone exists as isolated particles. It is the conclusion of many engineers, because of the conditions described, that when bituminous concrete pavements are to be employed either type (*a*) or type (*c*) should be selected.

Type (*c*).—During recent years, the bituminous concrete pavements of this type which have been most extensively employed are known as Bitulithic, Warrenite, and Topeka.

Bitulithic and Warrenite—Differentiation.—The general use of Bitulithic and Warrenite bituminous concrete pavements throughout America has brought up for discussion the matter of the fundamental differences between these two types of patented pavements. It is believed that it will be of interest and value to the engineering profession to submit the following statement, prepared by Mr. George C. Warren, president of the Warren Brothers Company, for the information of the engineers enrolled in the Graduate Course in Highway Engineering at Columbia University:—

"Bitulithic and Warrenite mixtures are both made under the provisions of the Warren patents, which the courts have held 'cover the product no matter how produced.' Bitulithic is designed to meet the conditions generally prevailing on city streets, and Warrenite is to meet such conditions as may arise on country roads so as to meet the physical and economic conditions and public demands as to cost.

"Generally speaking, Bitulithic is mixed by a plant which is too cumbersome to meet country road conditions, which provides for combining the materials proportioned by separation of sizes of the aggregate, after heating, and then recombining by weight.

"Warrenite is, generally speaking, mixed by a plant so portable that it may be set up either alongside the railroad; along the side of the road being constructed, or in the quarry or gravel bank from which the bulk of the aggregate is being procured as may be most economical in any particular case. This plant is constructed on the principle of proportioning the several separated sizes by careful measurement by bulk before heating and retaining the batch so measured as a separate entity through the process of heating and delivery into the mixer in which the bituminous cement is added.

"Generally speaking, Bitulithic is mixed by a plant fine aggregate of Bitulithic, while sand predominates in the fine aggregate of Warrenite; also, fine crushed stone and sand respectively are correspondingly used for the seal coat aggregate.

"In the selection of quality of material (whether gravel or crushed stone) for the coarse aggregate a greater latitude is permitted in the case of Warrenite to practically meet the conditions of less opportunity for selections which are liable to prevail in localities considerable distance from railroad centres. This latitude is allowed, because, while the traffic conditions on country road thoroughfares are in point of weight and concentration of traffic rapidly becoming fully as severe as on most city streets, there is the important difference that on country roads generally the traffic is more exclusively of the motor vehicle rubber tire type and consequently less exaction in physical properties of the quality of the stone forming the basis of the aggregate is necessary. Also, unfortunately, many city streets are abused by constant excessive sprinkling or daily scoured by pressure flushing machines, a practice which is more or less injurious to any road surface, while country roads are seldom, if ever, wet except by rainfall; therefore, in cases where the very best quality of stone is unavailable, it would be safe to use stone of slightly lower quality in Warrenite on a country road although the same quality stone might not be safe for use in Bitulithic on a city street."

Topeka.—In many specifications the mineral aggregate for the Topeka pavement specified has been that contained in the decree of 1910, namely:—

Bitumen, from 7 per cent to 11 per cent.

Mineral aggregate, passing 200-mesh screen, from	5% to 11%
" " " 40 " " "	18 " 30
" " " 10 " " "	25 " 55
" " " 4 " " "	8 " 22
" " " 2 " "	less than 10%

Many unsatisfactory pavements have resulted by the unintelligent use of this grading. It has been found necessary, in order to secure successful results, to specifically define the character of the sand or other fine material which shall be employed in order to secure a satisfactory grading. Many specifications now cover the sand grading with almost the same care as in the case of sand grading requirements for sheet asphalt pavements. In order to encourage the use of a more satisfactory grading for this type of pavement, the American Society of Municipal Improvements in 1915 recommended the adoption of the following grading:—

Passing 200 mesh screen		7—10%
" 80 " "	but retained on a 200,	10—20%
" 40 " "	" " " an 80,	10—25%
" 20 " "	" " " a 40,	10—25%
" 8 " "	" " " a 20,	10—20%
" 4 " "	" " " an 8,	15—20%
" 2 " "	" " " a 4,	5—10%

The South Indian Railway Administration will make surveys for a metre gage line from Jayankonda-Sholapuram to a point on the proposed Panruti-Trichinipoly Railway, as close as possible to Trichinopoly, on the north of the Coleroon, a distance of approximately 50 miles. This survey will be known as the Jayankonda-Sholapuram-Trichinopoly Railway Survey.

It is reported from Petrograd that a special commission, composed of representatives of the Government, commerce and industry, will meet shortly to examine the Bill prepared by the Ministry of Commerce to facilitate the development of the use of electric power in works and factories. The Bill has been prompted by the frequent crises in connection with the coal in Russia.

EXPERIMENTS IN CHECKING THE SLIDES AT PANAMA.

A PAPER by Gen. Geo. W. Goethals in the "Canal Record" will be of interest to engineers in general, describing as it does methods which have been used in the attempt to stop slides in the Panama Canal. In this work the engineers have been up against problems which they have never before experienced and the results of their experiments will be of great value in future on similar works. The results of these experiments are summarized in the following :—

The various slides began without any warning, and there were no means of determining the extent to which they would proceed. Various attempts were made to check them, but all without success. There is no question that the excessive rains were responsible in a great measure for most of them and for the difficulties that resulted because of them ; yet some of the most troublesome ones occurred during the dry season. Drainage proved ineffective. The rains, which cover a period averaging nine months of the year, so thoroughly saturate the ground that, though the surface may be dried out by the wind and sun during the remaining three months, the ground water remains. Because of the great depth of the cutting subsurface drainage could not reach the ground water sufficiently deep to be effective, even if the excessive cost involved warranted such a procedure. It has been suggested that artificial heat be applied through pipes, but the cost precluded such a method of relieving the situation ; furthermore, the relief would be temporary.

Planting the slopes with grasses and vegetation prevents, to a certain extent, the erosion that follows some of the heavy downpours, but even in places where this has been done the results anticipated were not secured. The trees that have been standing on the banks for years slide down, standing erect in their normal positions, with slides of the second class and in the movements that take place subsequent to the "breaks."

Piling was tried with the hope that with the ends of the piles in firm ground the loose or moving portion might be retained in place. This also proved a failure, and along some portions of the banks are now seen piles projecting at various angles and at different elevations, though originally the piles were driven vertically and they were properly aligned.

Where the moving mass was clayey material loosened up by the movement and by the rains, a covering of heavy riprap was resorted to with the hope that their weight would carry the pieces of stone through the mass to the solid ground below and thus check, if not stop, the movement; much of this riprap was subsequently removed from the prism by the shovels.

It was believed that blasting was in some measure responsible for the slides, on the theory that the shaking up of the banks, caused by the blast, destroyed the cohesion of the particles in the banks, resulting in their breaking down, so that steps were taken to reduce the depth of the holes and the amount of explosive used, in order to lessen, if not remove, any source of trouble on this account.

It was learned that in experimenting with clays for the manufacture of pottery the Bureau of Standards has discovered a means of removing the slipperiness from the clays by inoculating the soils with a simple and inexpensive solution. With the hope that some such method of preventing the slides might prove effective with the soils on the isthmus, samples were sent for experimental purposes along these lines, but it appears that these clays are of an entirely different character, and no method of treatment has yet been evolved to secure the results desired.

The construction of retaining walls to withhold the moving masses was not possible, for access to the sides of the prism where the walls belonged could not be had. When access was possible, the movement had ceased, there was no evidence of any further movement and the desirability of or necessity for walls no longer existed.

Some of the sandstones and shales in the cut when exposed to the air disintegrate, but harden when kept constantly wet. Where disintegration occurred, the resulting soil would grow grasses and vegetation, and steps were taken to protect the slopes and the underlying material in this way, assisting nature to some extent in a country where vegetable growth springs up and expands rapidly.

Experiments were made with cement covering applied to the banks by the cement gun and by concrete held in place by rods embedded in the rock ; neither proved successful, and they were abandoned.

When the use of concrete proved a failure, the geologist thought that experiment might develop a solution which, applied to the face of the sandstones and shales, would combine chemically with the substances in these rocks, so as to form a coating of glass. Experiments were made, but no satisfactory solution obtained.

With the breaks, except those which occurred in the vicinity of La Pita Point, lightening the banks, where this could be done, secured good results, as did also the sluicing of the upper portions of the hills around Cucaracha slide into the valley on the opposite side of the hills from the prism ; but in all other cases the only effectual method found was to allow the material to enter the cut and remove it. This procedure has resulted in bringing all the slides to a state of rest, and with the exception of those now active none of them has given any trouble since, for there has been no movement of any kind in any of them after all the material that was in motion had been removed or come naturally to rest.

It is certain that the troubles are due to the failure of underlying strata, because these were unable to bear the weight that the banks brought upon them. Under the circumstances it is difficult to understand the impression that has gained credence in some quarters that a sea-level canal would have avoided the difficulties encountered, since the cutting would have been through the same material, but at least 80 ft. deeper.

It is also certain that nothing can stop the movements now in progress until the angle of repose is reached for the materials under the conditions that exist and that this can be reached only by removing the excess amount of material. If experience counts for aught, then that gained in the handling of the slides and the breaks that have occurred along the line of the canal leaves no doubt that the means adopted and now in use will effect a cure in the slides that now close the canal ; furthermore, that when cured, no further troubles need be anticipated from slides in this locality.

The construction of the Altai Railway, which connects Novonikolaievsk on the trans-Siberian with Semipalatinsk in the Steppes Provinces, passing through Barnaul, in the Tomsk Government of Siberia, has recently been opened to traffic. This railroad, 500 miles in length, will serve the richest agricultural and mineral regions of Siberia. The Altai region has deposits of gold, silver, lead, zinc and copper, which were worked in the eighteenth and nineteenth centuries, but afterwards abandoned owing to lack of transportation facilities and other causes.

THE LEGISLATIVE CONTROL OF ENGINEERING PRACTICE.*

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THERE is a growing tendency among certain engineers to attempt to remedy some of the troubles in the engineering profession by means of legislation, limiting those who can legally practise to engineers having certain qualifications.

This question has been before the public for at least fourteen years, the American Society of Civil Engineers having published a discussion of the subject in transactions of 1901. Although many bills have been drawn and submitted to the legislatures of the various States, very few have become laws.

The opposition to the passage of these proposed Acts has come from within the profession and not from the general public.

The reasons advanced for advocating the licensing of the profession come under two classes: Self protection, and public protection.

Self Protection.—We are all familiar with the rodman who, having been endowed by Nature with a vivid imagination, a superabundance of self-confidence and a glib tongue, hires an office, hangs out his shingle, fakes his experience and poses as a consulting engineer. On his card we find C.E. after his name, although he has never been inside of a technical school. He claims to belong to some half a dozen societies, the principal qualification for membership in which is the ability of the applicant to pay the admission fee.

Should not the competent engineer be protected from this class of fakers? Doctors, lawyers, and even school teachers are required to have certificates before they can practice. Why not the engineer?

Several States across the line have passed laws licensing architects which are so drawn that a structural engineer cannot practice his profession without taking out a license as an architect.

The Illinois law defines a building as anything with foundation, roof and side walls.

This includes anything from a hog-pen to a thirty-story building and an architect's license must be obtained before designing either.

Should not the engineer be protected from unjust laws of this kind?

Some of the bills introduced have had as their avowed purpose the cutting out of competition. This reduces the profession to the level of a trade union. In fact, if we go before the public asking for special legislation on the grounds of self-protection we lower the dignity of the profession in so doing.

The only grounds upon which we should ask the public for legislative control of the engineering practice is that of public protection.

The public needs protection because they are not in a position to judge of the ability of an engineer.

An engineer's ability must be inferred from either his education, his works or his membership in the strictly engineering societies.

If the problems of engineering design, construction and operation were merely matters of figures the man fresh from college would usually qualify as the best engineer. Many men leave our institutes with this view but soon find that long before the time for applying formulae is reached the scheme must be viewed by an engineer of sound judgment based upon long experience.

Diplomacy, tact and good judgment are so essential in all engineering operations that any attempt to judge an engineer by mere degrees and diplomas is likely to prove a failure.

Can the public judge his ability by his works?

Unfortunately, popular descriptions of engineering works do not find their way into the public press except occasionally and the public does not read the engineering press. An engineer's works do not always indicate his ability. A badly designed bridge may stand for years a menace to the public and finally go down when the critical load comes on it.

A dam may stand until a flood comes.

It takes time to demonstrate the ability of an engineer by his works.

Membership in engineering societies should be a good criterion by which to judge the ability of an engineer. In other words, how does he stand in the profession? What do his associates think of him? They are in a far better position to correctly estimate his ability than the public in general.

The committee of the American Society of Civil Engineers, appointed to consider this matter, while reporting against the general principle of licensing engineers, realized that there were many engineers who favored the idea and that many very inferior acts had been drawn up and submitted to the law-making bodies for enactment. Should some of these pass, licenses would be issued to men totally incompetent, thus deceiving the public instead of protecting them.

The committee, therefore, draughted a Model Bill to be used as a basis for proposed legislation.

The acts which have been proposed come under two classes: (*a*) Those which attempt to license all in the profession; (*b*) those which apply to engineers practising only in certain lines.

Many difficulties are encountered in draughting an act. The first trouble comes in defining to whom the act applies. Especially is this true under the first class of bills. In the Colorado Act submitted to the Legislature in 1910 the definition of the civil engineer was very broad: "A civil engineer, within the meaning of this act, is one who practises any branch of the profession of engineering other than military. Such profession embraces the design, inspection and supervision of the construction of public or private utilities which require experience and the same technical knowledge as engineering schools of recognized reputation presents for graduation, provided, however, that none of the provisions of this act shall apply to the practice of surveying."

You will note that this is so broad that it includes mechanical, electrical, mining and other engineers, and this was probably one of the reasons why the bill was defeated.

In 1914 the proposed definition was modified as follows: "The profession of civil engineering, within the meaning of this act, embraces the design, inspection and supervision of construction, and reports on the safety of public and private utilities which require experience and the same technical knowledge as engineering schools of recognized reputation require for graduation; provided, however, that none of the provisions of this act shall apply to the practice of surveying, and provided, further, that

* Abstract of an address before the Calgary Branch Canadian Society of Civil Engineers, March 16th, 1916.

the provisions of this act shall be limited to the services of engineers in the design, inspection and supervision of construction, and reports on the safety of any structures or works on any of the following kinds or classes of structures and works.

"(1) Bridges 16 feet or more in length or other structures requiring a determination of stresses and strains for their design, on public highways or roads open to the use of the public, or on steam or electric or other railroads.

"(2) Structures built of stone, plain concrete or reinforced concrete.

"(3) Structural steel structures including steel in buildings and similar structures when said buildings or structures are three or more stories in height; also steel in mill buildings, steel in grain elevators, steel in mine and mill structures, steel in industrial buildings, and steel in plants and steel in structures on ditches, canals, sewers, waterworks and power plants.

"(4) Canals, ditches and conduits having a capacity of fifty cubic feet per second or more.

"(5) Sewers and sewer systems and sewage disposal plants; water supply plants for domestic use, and power plants, including power plants for irrigation.

"(6) Dams and reservoir embankments of a height of ten feet or more.

"(7) Mill and power plant buildings of timber, brick, concrete or any combination of these materials and electric transmission lines.

"(8) Timber bridges, trestles or structures for mill, mine and industrial plants, grain elevators, ditches, canals, sewers, waterworks and power plants.

"(9) No maps, plans, designs, reports, statements or filings to be certified or approved by an engineer shall be accepted or filed by any State official unless the certification or approval is executed by a person duly licensed in accordance with the provisions of this act.

"All maps, plans, designs, reports, statements or filings prepared by or under the direction of a licensed engineer shall bear the name of such engineer accompanied by the words 'Licensed Engineer, State of Colorado.' "

In as much as the Canadian Society of Civil Engineers proposed to ask Parliament to define the term "civil engineer," it will be interesting to note an old definition which appeared in Ree's Cyclopaedia, 1st Am. Edition, published in Philadelphia, 1819:

"Civil Engineer—a denomination which comprises an order or profession of persons highly respectable for their talents and scientific attainments and eminently useful under this appellation as the canals, docks, harbors and light houses, etc., amply and honorably testify." It is worthy of note that our ancestors were highly respectable and useful members of society.

The underlying principle in these definitions is construction. Surveying and hydrography are only minor parts of civil engineering.

A man who is exclusively a land surveyor or exclusively a hydrographer is not a civil engineer.

The proposed Alabama Act of 1911 divides the profession into civil engineers, mining engineers and surveyors:

(1) A civil engineer is defined as any one capable of designing and supervising the construction of any public bridge, railroad, sewer, sewage disposal plant, filters, waterworks, ditches, mines, tunnels or works of similar nature.

(2) It provides that all maps for public record must be certified by a licensed surveyor.

(3) Drawings, specifications and estimates for public record must be certified by civil or mining engineer.

(4) No construction work shall be supervised or directed and no public employment as engineer shall be held except by licensed engineers.

Proposed Indiana Act.—Provides (1) no person may design, lay out or superintend or act as chief engineer of any work that may be classed as civil engineering work or hold office as city engineer in that state without obtaining a license.

The next serious question that arises is, What qualifications must an applicant have in order to receive a license.

In the Colorado Act.—The Board of Examiners may issue a license upon examination or upon the record, training and experience of any applicant who has practised civil engineering for a continuous period of not less than ten years immediately preceding. In order to be admitted to examination a candidate must be qualified as follows: (1) More than 25 years of age; (2) good moral character; (3) engaged actively in civil engineering work for at least six years and in active charge of work for at least one year; or (4) graduate of engineering school of recognized reputation and has been actively engaged in civil engineer work for two years with active charge of work for at least one year.

Every act contains a provision known as the grandfather clause. In the Colorado Act this provides that during the first year the board of examiners *shall* accept as proof of the candidate's capacity to perform the duties of a civil engineer, the record, training and experience of any candidate who possesses the qualifications for admission to examination. This means that practically all who have been practising for six years with responsible charge of work for one year would be admitted during the first year.

Licenses and examinations are in three classes: (1) Irrigation and hydraulic engineering; (2) municipal, hydraulic and sanitary; (3) structural engineering.

Under the Proposed Alabama Act.—Licenses are issued as follows: (1) On examination. (2) To all practising in the state at time of passage of the bill (grandfather clause). (3) Graduates of University of Alabama and Alabama Polytechnic after two years' experience for surveyor. After four years' experience for civil engineer or mining engineer. (4) Non-graduates. After four years' experience for surveyor. After eight years' experience for civil engineer or mining engineer. (5) To engineers holding licenses from other states. (6) To members of American Society of Civil Engineers. (7) To members of Institute of Mining Engineers. (8) Any junior or military engineer in United States Civil Service.

Taking up those acts which license only a limited number of the profession.

The State of Wyoming passed a law in 1906 which has been in operation ever since. This law licenses only those who prepare plans or designs in connection with the use of water in the state or who apply for a permit to divert water.

Licenses are issued to the following: (1) Land surveyors on examination—plane surveying. (2) Topographical engineers on examination—plane and topographical surveying. (3) Hydraulic and hydrographic engineers on examination—plane surveying and hydraulics. (4) Construction and designing engineers on examination

—plane surveying; design of irrigation works and structure computation of earth work. (5) Administrative engineer on examination—plane surveying; hydraulics; construction work; irrigation; law and practice.

Within four years after the passage of this law 200 men had qualified under it and all had taken examinations except members of the American Society of Civil Engineers. As this is a very sparsely settled state I doubt very much if this law had any effect upon competition.

It is a serious question whether a license law really excludes the incompetent man from the profession. There are quacks still practising in the medical profession and incompetents in the legal profession in spite of the acts governing the practice.

It is suggested that strict governmental supervision of plans, specification and construction of all structures where the safety of the public is involved, combined with laws requiring a high qualification for engineers at the head of the departments, will result in a more effective public protection than any legislative attempt to control the engineering practice.

The qualifications for the heads of departments requiring engineering knowledge should provide for (1) a minimum residence in the country, province or state in order to ensure familiarity with local conditions. (2) Membership in one or more of the three national engineering societies—Canadian Society of Civil Engineers, American Society of Civil Engineers, or British Institution of Civil Engineers. The requirements for admission to the grade of member in all of these societies is high and the tendency is to stiffen the requirements. (3) A minimum amount of experience in the particular line of engineering, a knowledge of which is required in order to fill the position. The above suggestion has greater possibilities in it for public protection than any system of licensing engineers.

The proper method of handling the fake engineer is through the local branches of these national societies. His record can be investigated by them and shown up.

In addition to the above, these local branches can do a considerable amount of advertising which would be considered unprofessional on the part of the individual to the end that the public may be kept in touch with engineering matters and be made to realize that membership in these societies represents high qualifications as an engineer.

NEW EXPLOSIVE.

A new permitted explosive, known as Bellite No. 1, has been sanctioned by the Home Secretary of Great Britain. Its composition is as follows:—

	Parts by weight.	
Ingredients.	Not more than	Not less than
Nitrate of ammonium	65	62
Tri-nitro-toluol	16	14
Chloride of sodium	17·5	15·5
Starch	5·5	3·5
Moisture	2	–

It is stipulated that the explosive shall be used only when contained in a case of Manilla paper, fire-proofed and thoroughly waterproofed with a mixture of carnauba and paraffin waxes, and that the greatest weight which may be used in any one shot hole shall not exceed 20 oz. Four oz. gave a swing of 2.74 ins. to the ballastic pendulum compared with a swing of 3.27 ins. given by 4 oz of gelignite containing 60 per cent. of nitro-glycerine.

LETTER TO THE EDITOR.

Revision of the Patent Act.

Sir,—I believe that your columns are always open to a discussion of matters of general interest and importance to the engineering, manufacturing and industrial public.

Few matters are of greater or more vital importance, yet so little known, as the patent laws of a country, and their administration. Their one broad purpose is to encourage and stimulate improvement, advance or invention in every branch of human activity.

For many years it has been widely admitted that many considerable changes are very badly needed in the Canadian patent act and its administration.

The great growth of the Department of Agriculture, proper, has made ample work to occupy fully the time and attention of both the minister and his deputy. Yet the patent office has developed equally or to an even greater extent. It is the unanimous opinion of all who are experienced in the matter, that the patent office should have a separate and distinct head practically independent of any department though, possibly, nominally subordinate to the head of a department—similar to the arrangement in the United States, after which the Canadian patent law and practice is molded to a considerable extent.

Many very prominent corporations and individual business and professional men, and practically all important industrial associations and societies, have petitioned the government to appoint a commission to look into and revise the patent act and its administration.

Certainly there could be no time better than the present. There is in existence a commission with very wide powers of investigation with the purpose of finding ways and means to prepare Canada for her great future. Revision and administration of the patent laws is certainly one of the matters that will have a great influence upon future prosperity.

Why, then, is nothing done?

Since the enactment of the present patent act, the value and advantages of many of its provisions have frequently been tested. Some of them have been found defective and productive of far more evil than good.

The following suggestions arise from the experience of the leading manufacturing patentees and prominent patent counsellors and solicitors of the Dominion. It is their common desire to overcome these defects, greatly strengthen the validity of patents, remove some of the useless burdens now attached to patents, eliminate a great part of the clerical work of the department, increase the net receipts of the department, remove the more fruitful grounds for misunderstandings on the part of patentees, decrease the cost of patents to the applicants, provide for complete authentic official records in interferences and all other patent matters, eliminate all private bills for re-establishment of forfeited patents, and to avoid the doubt and discrimination of section 44. In general, to facilitate and improve the administration of the department, and encourage and stimulate invention, while at the same time maintaining the rights of the public. To those ends, the following amendments, with attached reasons, are suggested as indicative of the main points only:—

1. *Substitution of a single continuous term of eighteen years, with payment of the entire fee at time of filing, in lieu of the divisable term with instalment payment.*

The present total government fee for eighteen years is \$60. However, as shown by the records, less than 17% of the patents have more than the first \$20 paid. In the

year ended March 31, 1910, the total received for second and third term fees, was $21,960. During the same period, 7,216 original patents were granted. If the total government fee for eighteen years had been made $30 there would be a net increase of $50,200. Had the total government fee for eighteen years been $25 the net profit would still have been $14,120. In addition, many patentees would be holding valuable patent rights which, under the existing act, have become lost by accident, neglect, or impossibility of payment on the part of the patentee or parties by him entrusted with such payment. Furthermore, all private bills for the re-establishment of patents forfeited for non-payment would be avoided, and the embarrassing question of intervening rights of innocent third parties would be entirely eliminated. A considerable saving would result in the clerical work in the patent office. All endorsements, entries, and accounting in connection with the second and third term fees would be abolished. Nor can it be argued that a total of $30 for an eighteen-year patent would deter applicants. Many Canadian inventors take United States patents which run for seventeen years with payment of $35 total government fee before the patent is granted.

2. *Substitution of interference proceedings within the patent office in lieu of the present arbitration proceedings under section 20 of the act, or the corresponding Exchequer Court practice.*

All interferences originate in and are declared by the patent office. Therefore, they must become somewhat skilled in the subject. On the other hand, arbitrators appointed to hear and determine the issue of interferences are usually the attorneys of the respective applicants, either patent solicitors or lawyers. The average patent solicitor or lawyer handles only a very small fraction of the total applications filed. Obviously his experience in interferences is very limited as compared with that of the patent office. This has long been clearly recognized in the United States where the interference practice on most points is very similar. There an interference examiner gives his time exclusively to interferences, and the attorneys, instead of acting as arbitrators, argue their cases before him. One great and very valuable advantage thus gained is the right of appeal. The action of the interference examiner is the action of the commissioner and is, therefore, appealable. It is not appealable in the case of arbitration under the Canadian practice. It can not be denied that the question of priority in conflicting applications is very vital, and that the corrective effect of an appeal exists on many far less important questions. Why, then, should it not be granted in the case of conflicting applications? Furthermore, all possibility of fraud, collusion, etc., between the arbitrators in deciding the issue would be eliminated. It can not be denied that there is a very fruitful field for such practice under the present procedure. Two of the three arbitrators would be eliminated, with that much saving to the contestants, and the fees now payable to the third arbitrator would go to the department for the services of the interference examiner. The practice in interferences would become uniform and greatly simplified.

3. *Substitute for compulsory manufacture section 38a and compulsory license section 44, an optional choice between manufacture and compulsory license, the same to be applicable to all patents and to extend throughout the life of the patent except the first two years.*

No court has yet decided whether section 38a applies to process patents. There are many strong opinions both ways and the matter is very much in doubt. Hence all process patents not under section 44 are of very doubtful validity, simply because the law is very vague. Proof of non-manufacture is proof of a negative, which is exceedingly difficult. It is, therefore, nearly a worthless weapon, in the hands of the public, against the patent owner. It can not be said that such provision compels the patentee to manufacture in Canada. Where there is no demand, the most that is done is to make one of the patented devices, starting it within the two-year period, and dragging it along as slowly as possible. If there is an appreciable demand, the inventor is always very glad to made the invention as rapidly as he can sell it. He needs no law to compel him. Furthermore, it should be remembered that the inventor is the originator. No one else knew of the invention before he did. The public have no rights in it prior to his. Therefore, it can not be argued that he is in any manner injuring the public by not manufacturing or selling to the public; nor can it be said that section 38a has caused the building of factories here in Canada. If any section of the patent act has had any effect in that direction, it is clearly the section about importation.

Compulsory license applies to certain classes of invention only. To many it does not apply. Also, it does not apply to any unless specifically so requested within a limited time from the date of the patent. About one-sixth, only, of the annual issues of patents is placed under the compulsory license clause. That means from 1,300 to 1,500 petitions to be considered by the commissioner, an equal number of decisions to be made out and mailed, and about an equal number of endorsements and other record entries to be made. In many instances an extension of time to manufacture is sought. In each such case a rather lengthy petition with affidavits must be considered, a decision made and mailed, and an endorsement and entries made.

With the suggested change, all of these petitions, decisions, endorsements and entries would be completely abolished, the doubt about process patents would be cleared up, the public would be in just as strong a position to get or use the invention, all patents would be on the same footing and subject to the same conditions, and the validity of all patents would be greatly strengthened, because, to prove invalidity it would be necessary to prove both that the patentee would not grant a license and that he did not manufacture. This is very similar to the present British Patent and Designs Act.

4. *Consolidation of the trade mark and copyright branch with the patent office, and appointment of a commissioner who would give his time exclusively to the consolidated branch.*

The practice and procedure, the rights protected, the rules and regulations and the legal requirements in the two branches are in many respects similar, and most of the business of the two branches is carried on by the same profession—patent attorneys and lawyers.

W. S. BABCOCK,
Registered Patent Attorney.

Montreal, May 1st, 1916.

SUMMER COURSE IN SCIENTIFIC MANAGEMENT.

The fourth summer course in scientific management will be held in Providence, R.I., under the directorship of Frank B. Gilbreth, consulting engineer. The course, to which only a selected group of teachers and thinkers will be admitted, consists of lectures, laboratory work and visits to various plants where scientific management may be studied. The course commences on July 31st and terminates on August 12th.

COAST TO COAST

Quebec, Que.—The entrance piers of the new graving dock at St. Joseph de Levis have been completed and excavation work for the dock proper is well under way.

Winnipeg, Man.—An analysis of all public water supplies in the province has been ordered by the Provincial Board of Health. The recent epidemics are blamed on impure water.

Ottawa, Ont.—The Laprairie link of the new highway from New York to Montreal is to be finished this year. The cost of completing the work will be about $79,850, which will make the total cost about $150,000.

Ottawa, Ont.—Provision has been made for the appointment of a commission to study the railway situation in Canada. It is possible that the government has in mind the nationalization of both the Grand Trunk Pacific and the Canadian Northern Railways.

Simcoe, Ont.—The Lake Erie & Northern Railway management has extended that part of the local depot in which the electric installation for current will be placed, having changed its plans. The road will receive considerable Hydro current through Simcoe.

Vancouver, B.C.—The B.C. Electric Railway is completing the construction and equipment of the sub-power station near Horne Payne station on the Burnaby Lake Line, which was delayed two years ago, and a large gang of men is now at work on the building.

Toronto, Ont.—Work is now in full swing on the long-awaited Lansdowne Avenue civic car line. All the material necessary—rails, switches, poles and other supplies—are to hand, and are being rapidly placed in position. It is expected the line will be in operation before the fall.

Brantford, Ont.—Work on the L. E. & N. Railway between Brantford and Port Dover is progressing favorably despite the scarcity of labor. Overhead work as far as Waterford will be completed by the end of the week, and the company expects to have the line into Simcoe opened in a month.

Ottawa, Ont.—Frank Darling, architect of the Federal Plan Commission, in reply to a request of the Board of Control, in which an application for a building which was to be over the 110-foot height limit, was referred to him for report, objected strongly to the recommendation of the Commission being set aside, and held that the 110-foot limit should be preserved.

Montreal, Que.—Hollinger Gold Mines, Limited; Acme Gold Mines, Limited; Millerton Gold Mines, Limited, and Claim 13147 of Canadian Mining and Finance, Limited, all situated at Porcupine, Ont., two of them producers of yellow metal, are to be amalgamated with nominal capital of $25,000,000. Title of the new corporation is to be The Hollinger Consolidated Mines, Limited.

Montreal, P.Q.—The Canada China Clay Company is applying for a Dominion charter, the capital of the company is to be $1,500,000. The company owns a large kaolin deposit in Amherst Township, Que., and this will be connected up to the C.N.R. by a branch line. Tests carried out on the clay indicate that it is of high ceramic value and also may be used in the manufacture of high-grade paper and certain paint pigments.

South Vancouver, B.C.—The trunk sewer on George Street is almost completed; the progress on the Prince Albert Street sewer has during the past week been somewhat slower on account of the nature of the ground. A strata of hardpan mixed with heavy gravel and boulders has been met. Satisfactory progress is being made with the Commercial Street work, the trunk there being laid to within 135 feet of the intersection of Twentieth Avenue and Commercial Street.

Ottawa, Ont.—Discussion arose during a debate on the Canadian Northern Railway situation in regard to the passage of the two C.N.R. Niagara charter bills. It was commenced by W. A. Buchanan, who stated that as the C.N.R. held many charters in the Lethbridge district and had built no roads, it did not seem fair that they should be given permission to build in settled parts of Ontario when the West was in need of transportation facilities.

Winnipeg, Man.—Foundation work on the new Eaton building is well advanced. The retaining wall trenches on the east and south sides are ready for the concrete. The excavation for the basement is half finished. It is expected that the first steel girders for the skeleton will arrive about the middle of June. After that the progress will be fairly steady and rapid. Some of the grillage has already been delivered, but the sections that will have to be laid first will not get here until about June 15.

Calgary, Alta.—The large cement plant at Exshaw Alberta, which when working regularly employs about 300 men, will be reopened about the 1st of June, according to a statement of the manager of the Canada Cement Company at Calgary, A. H. McGuire. "The Calgary plant may be opened later," said Mr. McGuire, "but the Exshaw plant is the largest one in this district and the one best equipped to supply large quantities of cement at bottom cost of production because of its proximity to the cement rocks."

Sudbury, Ont. — Serious damage amounting to hundreds of thousands of dollars has been done by floods in this district. Dams and bridges on the Spanish and Vermilion Rivers have been carried away or badly damaged. The Spanish Pulp and Paper Company's dam at Onaping was carried away and the whole season's cut went with it. The C.P.R. bridge at Whitefish was damaged, the approaches being swept away. The Sudbury flour mills' dam at McPherson Falls, has been carried away. Several miles of Algoma Eastern Railway tracks are under water.

Westmount, Que.—In keeping with the progressive policy of this city an architectural commission is to be appointed who will pass on all plans. The city council is determined that the city will not lose any of its beauty and that no buildings, walls or monuments which are not in keeping with the general tone of the community will be erected. The commission will be composed of the mayor, the general manager, and the engineer of the city, all ex-officio; four architects, and any other persons that the council may appoint from time to time. Each member of the commission will act without any remuneration.

Collingwood, Ont.—The Collingwood Shipbuilding Company, Limited, successfully launched the steamer "Iocolite," the second of the oil tank steamers which they are building for the Imperial Oil Company, Limited. The Imperial Oil Company has awarded the builders three contracts for vessels of this class, and also an order for two larger ocean-going steamers, making five vessels in all. The ships are equipped with all the latest appliances for the rapid handling of oil cargoes, and have special arrangements for carrying either crude oil, gasoline and lubricating oils. The propelling machinery, boilers and other equipment have all been manufactured by the Collingwood Shipbuilding Company, Limited.

Editorial

UNITED STATES PROTESTS ONTARIO'S NEW POWER SCHEME.

Protesting against the diversion of water from the Niagara rapids, as planned by the Ontario Hydro-Electric Power Commission, Secretary-of-State Lansing of the United States has written an official "note" to the British Government. He says that not more than 40,000 second-feet can be diverted from the rapids without damaging their scenic beauty, and that it is therefore important to come to an understanding regarding a diversion of even 6,500 second-feet:

The Boundary Waters Treaty, which was ratified May 13th, 1910, by the United States and Canada, specifies that the United States can divert 20,000 cubic feet of water per second, and Canada 36,000 second-feet, from above Niagara Falls, for power purposes. Up to the present time, all the water that has been so diverted by the plants located at Niagara Falls, has been returned to the Niagara River above the rapids. But there is nothing in the treaty to specify just where the water is to be returned—whether above or below the rapids.

The Ontario Commission plan to divert about 6,500 second-feet from above the Falls, and to return the water (via a new channel) at a point near Queenston, below the rapids. Now Secretary Lansing reads the words "and return the water below the Falls and above the rapids" into the treaty.

If the treaty can possibly be construed in the meaning taken by Secretary Lansing, then the United States itself is by far the more serious offender, and has clearly established a precedent for diversions such as Ontario proposes. Between fourteen and fifteen thousand second-feet are being diverted down the Mississippi by the Chicago Drainage Commission. This is water which is diverted "above the Falls" and which is certainly not returned to the Niagara River above the rapids. It is used "for power purposes" too—under 16-foot head.

Then there is the Erie Canal. The treaty permitted 500 second-feet to be diverted into the Hudson River, and that 500 second-feet is not returned above the rapids. Power is also developed with that water, and it is stated that more than 500 second-feet are now being illegally diverted for that canal. And, as a matter of fact, only 4,000 second-feet are permitted for the Chicago Drainage Canal according to the treaty, the other 10,000 second-feet now being illegally used.

Even in Canada there has been precedent for such diversion without "return above the rapids." About 1,000 second-feet are used by the Cataract Power Company for the Welland Canal power development at De Cew Falls.

Diplomatic correspondence will result for some months, probably, as a result of the United States note, but there is no doubt of the outcome. The Hydro Commission plant—which will develop 300,000 h.p.—will be built.

A larger plant than 300,000 h.p. cannot be built now because the existing Canadian companies own rights aggregating 29,390 second-feet, and the present treaty allotment specifies a total diversion of 36,000 second-feet. The Commission might at some time, perhaps, buy out one of the companies and so increase its plant to 600,000 h.p., which is the amount that will really be soon required. As exclusively reported in the December 9th, 1915, issue of *The Canadian Engineer*, an order-in-council apportions the volume that may be used by the companies as follows: Canada Niagara Power Co., 8,225 second-feet; Electrical Development Co., 9,985 second-feet.; Ontario Power Co., 11,180 second-feet.

The United States has no grounds upon which to protest the Ontario Hydro's scheme, and after proper representations are made through the usual diplomatic channels, will undoubtedly gracefully acknowledge the error. Canada would have no objection to a diversion from the rapids of a similar amount by the United States, provided that in so doing the United States does not exceed the 20,000 second-feet allotted by the treaty. There is no reason, however, why the United States should ask Canada for an additional 6,500 second-feet allotment as the price of consent.

CORRECTION.

In a small "filler" paragraph at the bottom of a page in our issue of April 6th, 1916, it was carelessly stated that "The asphalt deposits found at Trinidad and the Red Sea are practically pure bitumen." The word "are" should have been "contain," as it is, of course, generally known that about 40 per cent. of Trinidad and Red Sea asphalt is not bitumen.

A reader of *The Canadian Engineer* has called to our attention the importance of making this distinction between "are" and "contain," because bitumen is the content upon which asphalt depends for its binding power, and therefore upon the percentage of bitumen in any asphalt depends the amount of sheet asphalt, asphaltic concrete or asphaltic macadam that can be laid with a ton of the asphalt.

LOAD OF VEHICLES ACT.

The province of Ontario has recently amended "The Load of Vehicles Act" for the purpose of regulating and limiting the load which vehicles will be permitted to carry upon the public highways.

The bill, which was originally introduced in 1915, was discussed and allowed to stand over for a year. When it was brought up again this year it was referred to a sub-committee for discussion, given its final reading, and is now law.

While a number of the States of the Union as well as certain European countries have a similar act, Ontario is the first of the Canadian provinces to make it a provincial measure.

In the early days of the good roads movement, an attempt was made to increase the width of tire and in this way limit the load per inch, but because of the large investment in narrow-tired vehicles regulations of that character seemed impossible of application.

Within the last few years the heavy motor truck has come to be more generally used. With its load of from four to eight tons, it has created new conditions with each succeeding increase in size and load, and each year the question of methods of regulating the wear and tear on our highways has led to more and more confusion.

The main provisions of the new bill are briefly:

1st. No vehicle shall carry upon the highway a load, including the vehicle, greater than twelve tons or more than four tons on any one wheel.

2nd. No vehicle shall carry a load, including vehicle, which will impose a greater weight than six hundred pounds per inch of tire on the highway. The use of flanges, ribs, clamps, or other attachments to the wheels or other parts of the vehicle is prohibited where such attachments are likely to injure the highway.

3rd. Permits will be granted by the authorities for moving object or vehicles over highways when the maximum allowable loading has been exceeded.

4th. Speed of traction engines and motor trucks carrying a weight in excess of four tons, including the vehicle, is limited to ten miles per hour. The maximum speed for a load of six tons on iron or steel tires is six miles per hour, while a speed of eight miles per hour is allowable if the vehicle is equipped with hard rubber or other similar tires.

The effect of this Act will be to make highway loads more uniform so that those who have to do with the construction and maintenance of our highways, and particularly those engaged in bridge design, will possess reliable information so far as the probable loading on highway bridges and culverts is concerned. Up to the present it has been necessary to design such structures between very wide limits, necessitating what has often been anything but an economical use of material.

PERSONAL.

M. T. CANTELL has been appointed municipal engineer of St. Vital, Man.

ALLAN PURVIS has been appointed general superintendent of the Eastern Division succeeding A. E. Stevens, transferred.

A. C. VOLKMAR, forester of the Riordon Paper Company, St. Jovite, Que., has been elected an associate member of the Canadian Society of Forest Engineers.

Lieut. ERIC G. KINGWELL, formerly city engineer of Kamloops, B.C., and now attached to the First Canadian Pioneers, is actively engaged in recruiting work for his battalion.

R. R. BRADLEY, forest engineer of the New Brunswick Railway Company, is preparing his final maps of the territory owned by that company and expects in the spring to undertake planting operations on a large scale.

Lieut. FRANK J. LAWSON, B.A.Sc., recently with the engineering department of the city of Calgary, has died of wounds received in France. He was the only son of the well-known architect, F. J. Lawson, of Calgary.

VALDIMAX J. MELSTED, B.Sc., A.M.Can.Soc. C.E., until recently engineer of water services and tests for the C.P.R. at Winnipeg, has been engaged to conduct analyses of all the public water supplies in Manitoba. Mr. Melsted was appointed by the Provincial Board of Health.

J. W. HARRIS, M.L.S., M.Can.Soc.C.E., after 37 years' service to the city of Winnipeg as assessment commissioner and city surveyor, has handed over his departments to his successors, Leo. W. Donley and R. H. Avent, and his name will be inscribed on the civic pension roll.

Major HOWARD L. BODWELL, A.M.Can.Soc. C.E., according to recent casualty lists, has been wounded. He is a graduate of the Royal Military College, Kingston. For some time he was adjutant of the 47th Battalion and later joined the Second Pioneers, in which battalion he received his wounds.

Lieut.-Col. GEORGE G. NASMITH, Ph.D., C.M.G., who has rendered such signal service at the front as analyst and advisory offices on sanitary work for the Canadian forces, is to be honored by the University of Toronto with the honorary degree of LL.D., at the convocation to be held May 19th.

STANLEY H. FRAME, A.M.Can.Sco.C.E., has recently received the appointment from the Dominion Government as District Hydrometric Engineer with the Irrigation Branch, Department of the Interior, Calgary. For the past three years he held the position as assistant to the city engineer of Calgary.

A. E. STEVENS, now general superintendent of the C.P.R. at Montreal, has been appointed general superintendent of the Saskatchewan division with headquarters at Moose Jaw. The appointment was made necessary by the extended leave of absence, on account of ill-health, having been granted to J. G. Taylor.

AUGUSTIN FRIGON, C.E., has resigned from the firm of Surveyer & Frigon, consulting engineers, Montreal, to become engineering manager of the Canadian Siegwart Beam Co. Mr. Frigon is a graduate of Laval University, and for several years past has been a member of the Faculty of that university. The firm name of Surveyer & Frigon has been changed to Arthur Surveyer & Co. Mr. Surveyer's research work in regard to water-powers is well known to our readers. He is a member of the Canadian Society of Civil Engineers, the Société des Ingénieurs Civils de France, and the International Association of Navigation Congresses.

CANADIAN SOCIETY OF CIVIL ENGINEERS—COMMITTEE ON PRESTIGE, ETC.

Referring to the elections recently held in the various districts of the Canadian Society of Civil Engineers for the selection of members for the committee on prestige, influence, etc., the Council of the Society announces the following results:—

Representing District No. 1—W. J. Francis, Phelps Johnson, R. S. Lea, H. H. Vaughan, W. F. Tye and A. Boyer.

District No. 2—D. H. McDougall, W. A. Duff and L. H. Wheaton.

District No. 3—A. E. Doucet, A. Amos and A. R. Decary.

District No. 4—John Murphy, R. deB. Corriveau and G. B. Dodge.

District No. 5—H. E. T. Haultain, R. W. Leonard and E. W. Oliver.

District No. 6—H. B. Mucklestone, W. L. Mackenzie and A. J. McPherson.

District No. 7—H. F. Hayward, D. O. Lewis and E. A. Cleveland.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The nineteenth annual meeting of the American Society for Testing Materials will be held at Atlantic City, June 27th to 30th inclusive. The new Hotel Traymore has been selected as the headquarters for the meeting.

Volume 30. Toronto, May 18, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

RETAINING WALLS ON BATHURST STREET HILL, TORONTO

A DISCUSSION ON THE DESIGN AND CONSTRUCTION OF THESE RETAINING WALLS WHICH WERE BUILT TO IMPROVE THE ROAD AND PROVIDE BETTER ACCESS TO THE RAPIDLY GROWING NORTHWEST SECTION OF THE CITY.

By S. G. TALMAN, A.M.Can.Soc.C.E., A.M.I.E. (South Africa).
Roadways Section, City of Toronto.

IT is at once apparent from a glance at the sketch map of the city of Toronto, as shown in Fig. 1, that a good road connecting up the newer sections of the city north of the Hill, which runs along the old northern boundary, is an absolute necessity for the proper development of this district. It will also be seen that the centre of population of the city is rapidly approaching the vicinity of the intersection of Bathurst and College Streets, although perhaps the latter is not so evident to the person who is unacquainted with the city and the spreading out of its boundaries to take in the fast-growing suburbs. Before the city improved this roadway the Bathurst Street hill was a thing to be avoided on account of its steepness, although a ramp from Davenport Road on the east made matters easier for horse-drawn vehicles. The old road—that is, Bathurst Street proper—was of corduroy and the only drainage provided was in gutters on the side. As the material was of hard clay this did not matter much, and it took quite a severe rainfall to cause any damage. The ramp, which was of macadam, led from the top of the hill at Bathurst Street and had a maximum grade of 14.2 per cent. in dropping down to the elevation of Davenport Road, which is the road running along the foot of the hill. Such conditions, however, could not last long if the future development of the district was to be taken into account. It was necessary to go to Yonge Street, which was 1¼ miles east, in order to find a good road for taking up heavy loads, so that the improvement of Bathurst Street hill was obviously the duty of the city to the district.

East Wall—Reinforced Concrete Section.

West Wall—Concrete Gravity Section.

Work was commenced in March of 1914, the grading giving relief work to the local unemployed. Approximately 17,200 yards were handled, the spoil being used for fill at the foot of the hill. The maximum cut on the hill, exclusive of the old works, was 11.5 feet, and the maximum fill on the Davenport intersection was 7 feet.

Reinforced concrete walls were designed for the east side and plain gravity walls for the west. A more satisfactory treatment of the west side would have been by terracing, plans for which were prepared by the city but failed to receive the sanction of the property owners interested.

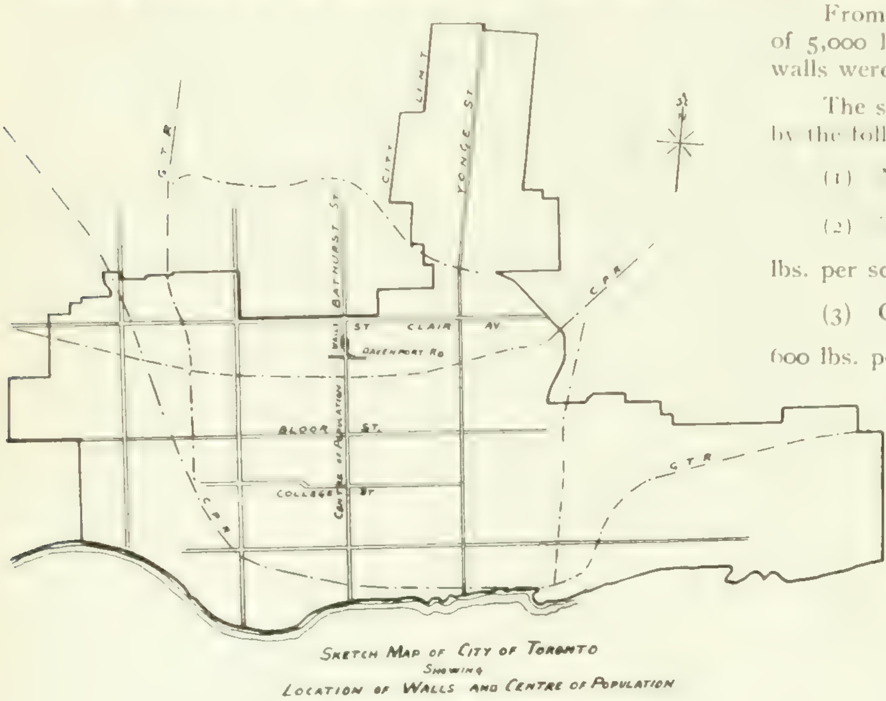


Fig. 1.—Map of City of Toronto.

From tests on the site an allowable bearing pressure of 5,000 lbs. per square foot was decided upon and the walls were designed to fulfil this requirement.

The stresses in the steel and concrete were calculated by the following formulæ:

(1) Neutral axis $= [\sqrt{(r^2m^2 + 2rm)} - rm]\, d$

(2) Tension in steel $= \dfrac{B}{r\,b\,d^2\,(1 - \frac{1}{3}k)} = 16,000$ lbs. per sq. in.

(3) Compression in concrete $= \dfrac{2B}{k\,b\,d^2\,(1 - \frac{1}{3}k)} = 600$ lbs. per sq. in.

Where

b = breadth of the beam in inches.
d = effective depth of the beam in inches.
n = distance of the neutral axis from the compressed edge of the beam in inches.
$k = \dfrac{n}{d}$.
A_c = bd square inches.
A_t = area of tensile reinforcement in square inches.
$r = \dfrac{A_t}{bd}$.
E_s = elastic modulus for steel in tension.
E_c = elastic modulus for concrete in compression.
$m = \dfrac{E_s}{E_c} = 15$.
B = bending moment in inch-pounds.

The notation being that approved by the Concrete Institute (England).

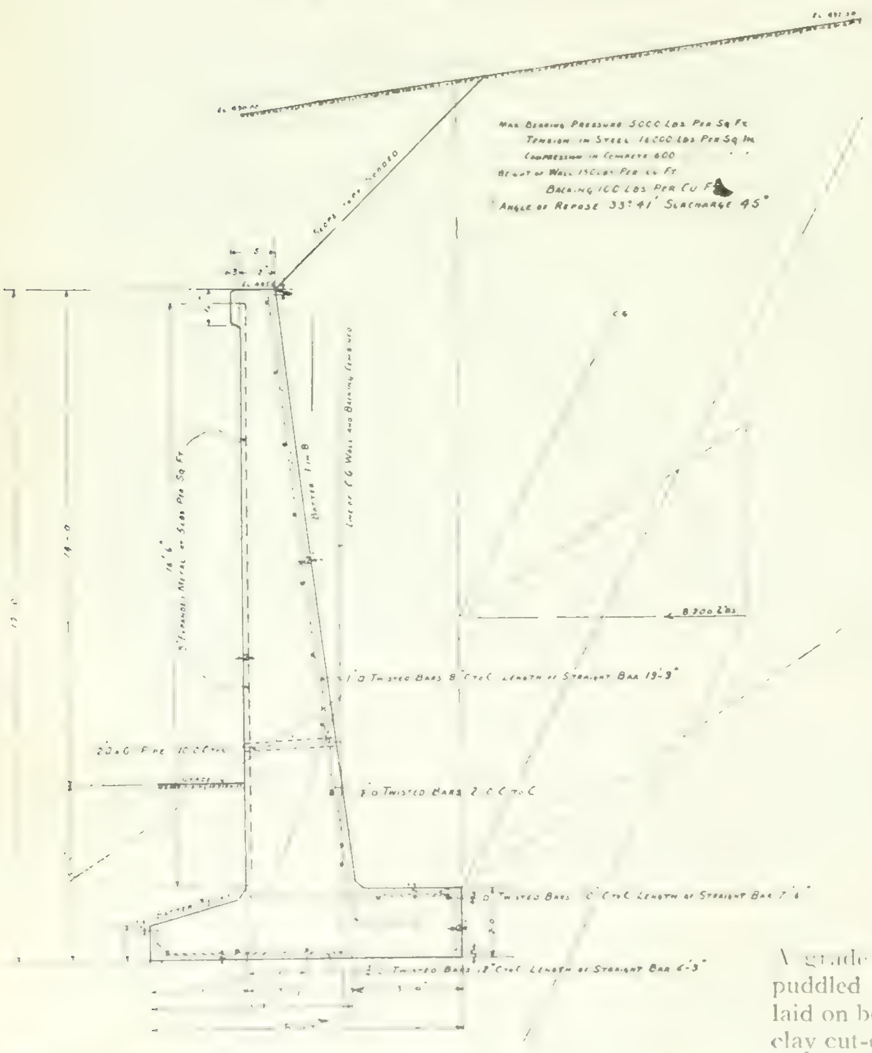


Fig. 2.—Detail of Reinforced Concrete Section of Wall.

A detail of the wall at its highest part is shown in Fig. 2. The longitudinal reinforcing is ½-inch square twisted bars spaced 2 ft. 0 in. centre to centre. The face of the wall has 3-inch expanded metal @ 5 lbs. per square foot, which gives practically the same area as ½-inch bars would have done, and is, in the writer's opinion, a far more satisfactory distribution of the steel for that part of the wall.

The trunk is reinforced with 1-inch square twisted bars at 8 ins. centre to centre, the heel has ¾-inch square twisted bars at 10 ins. centre to centre, and the toe has ¾-inch square twisted bars at 12 ins. centre to centre. The concrete used was a 1:2:4 mix, fairly wet, the aggregate being ¾-inch limestone with a specific gravity of 3.07.

The mixers were placed so as to allow the concrete to gravitate to the forms.

The construction offered no special features excepting in the vicinity of station 3 + 50 (Fig. 3), where a water-bearing stratum was struck, necessitating the use of a certain amount of timber sheet piling and special drainage, a general idea of which is given in Figs. 3 and 4. A grade was formed on the heel of the walls with well-puddled clay and three 3-inch diameter tile drains were laid on boards resting on the clay. At intervals a puddled clay cut-off wall was inserted in the line of tiles to prevent scouring action.

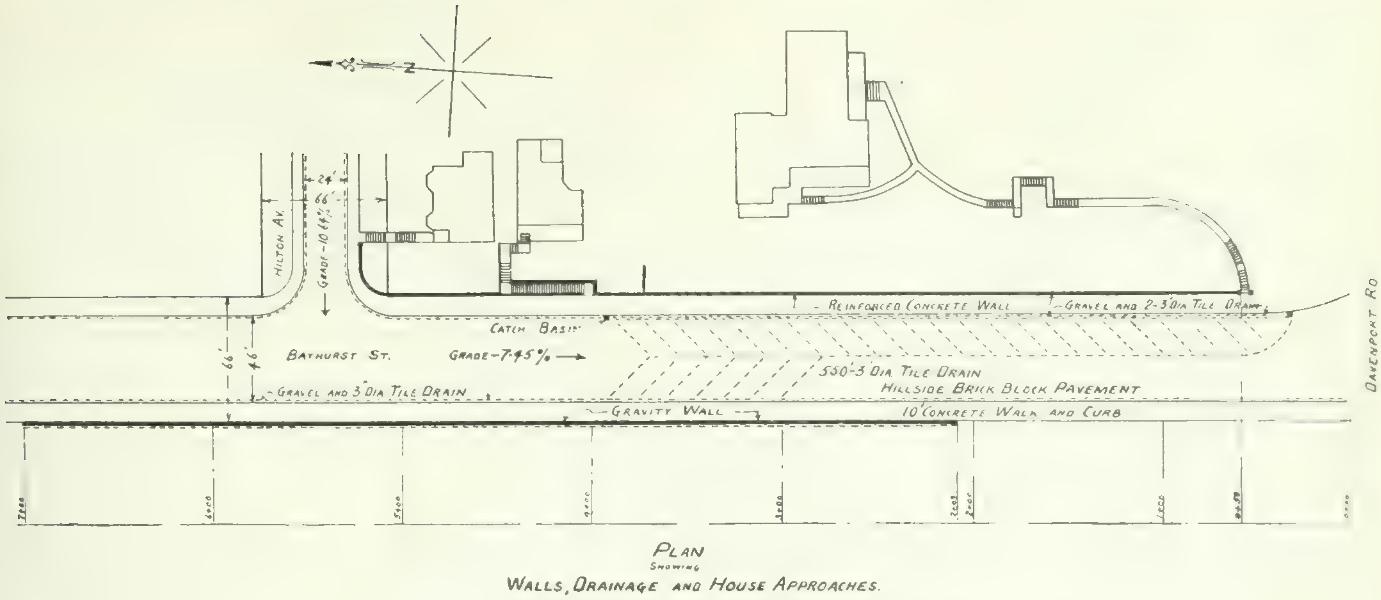


Fig. 3.—Sketch Plan Showing Location of Walls on Bathurst Street.

In such a wall the question of expansion and contraction is a very important one. In order to take care of this, expansion joints (shown in detail in Fig. 5) were placed at intervals of 40 feet in both the reinforced concrete wall and the gravity wall. The back of the gravity wall was given a considerable batter at the top and in order to prevent the action of frost on it, the wall was given a coat of hot asphalt.

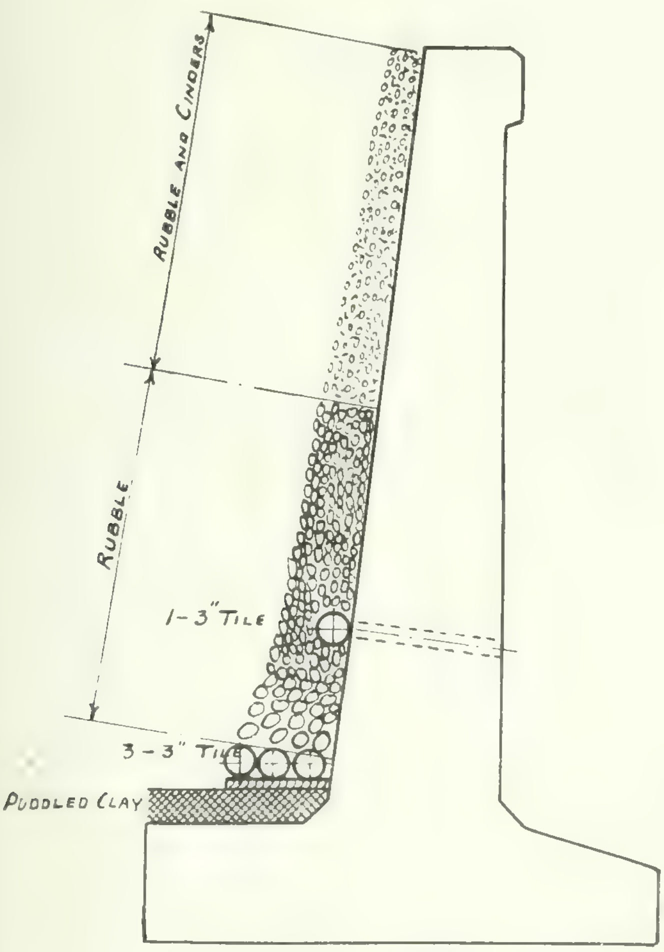


Fig. 4.—Section Showing Drainage System.

As the wall is on a street which not only carries big traffic but is in a fine residential section it was necessary to make its appearance pleasing to the eye. To do this, a scheme of panelling was carried out, the panels being moulded in the face of the wall. A general idea of their construction can be gathered from Fig. 6. These, in conjunction with the coping and the changes in elevation of the top of the wall, help to relieve the usual inartistic appearance of concrete construction.

The pavement on this section is hillside brick block on 6 inches of concrete, and was opened to through traffic by Mayor Church on September 25th, 1915.

It is worthy of note that the wall has withstood several severe rainfalls during its construction. The worst of these occurred last spring when the banks were still unsodded. In this case a surcharge of several feet over

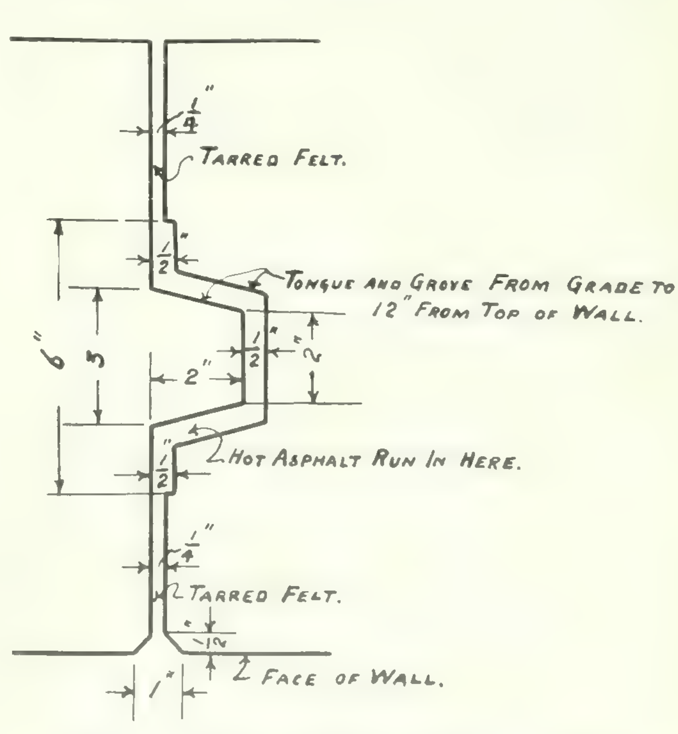


Fig. 5.—Detail of Expansion Joint in Wall.

the top of the wall was held up. This surcharge of sand had been washed down against some of the form work from the slopes above and, of course, was heavily laden with water.

A few details, such as railings along the top, some sodding on the slopes, etc., remain to be completed.

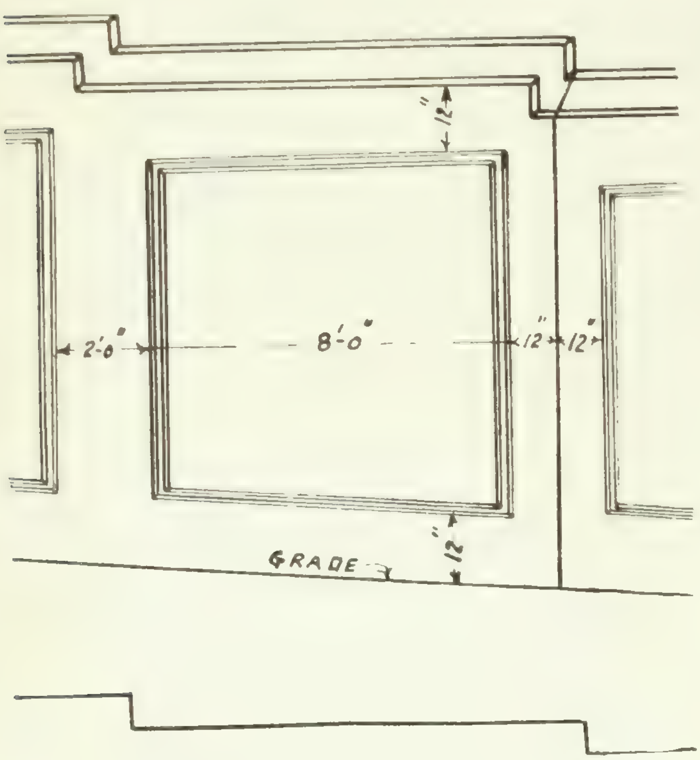


Fig. 6.—Detail of Panelling of Wall, also Showing Location of Expansion Joint.

The cost of the work will be approximately $260,000, and in view of the important bearing the street will have on the future of the city of Toronto the taxpayers' money could hardly have been better invested.

RAILWAY EARNINGS.

The following are the weekly railroad earnings for April:—

Canadian Pacific Railway.

	1916.	1915.	
April 7	$2,4[illegible]2,000	$1,7[illegible],000	+ $71[illegible],000
April 14	2,577,000	1,701,000	+ 876,000
April 21	2,[illegible]4[illegible],000	1,023,000	+ 720,000
April [illegible]	3,10[illegible],000	2,074,000	+ 1,002,000

Grand Trunk Railway.

April 7	$1,155,486	$1,008,320	+ $147,160
April 14	1,024,505	864,058	+ 150,847
April 21	1,050,661	860,772	+ 189,889
April [illegible]	1,445,853	1,263,028	+ 182,825

Canadian Northern Railway.

April 7	$ 677,000	$ 457,000	+ $220,000
April 14	668,000	463,700	+ 205,200
April 21	634,000	442,300	+ 192,000
April 30	844,100	585,900	+ 258,200

The gross earnings for three transcontinental roads for the first four months of the calendar year show the following gains:—

Month:		
January	$14,724,216	+ $3,006,033
February	14,667,935	+ 3,237,870
March	17,344,243	+ 3,731,5[illegible]0
April	18,077,805	+ 4,050,127

DESIGN OF MASONRY AND CONCRETE ARCHES.*

By R. J. Williams, BS.C. (Eng.).

MOST masonry and concrete arches which have been erected in this country appear to fulfil the primary condition of strength and stability which every structure must satisfy. It is a rare occurrence for an arch to collapse, and this, perhaps, accounts for the fact that the theory of the arch is not better understood.

It is, however, doubtful if many existing arches have been designed with due regard to economy, and the cost may probably be much decreased, as explained in Table I., by a proper method of design. In view of the great number of bridges which will have to be rebuilt in different countries on the termination of the war, when money will be scarce, the design of arches ought to receive more attention from practical engineers than has hitherto been the case.

It is not proposed in this article to deal with the subject from the mathematical point of view, though most of the results have been obtained by mathematical calculations. Mathematicians too often leave problems at the stage when they begin to be of interest to the engineer, with the result that their investigations have not been of such service as they might otherwise have been. It has been considered preferable to give sufficient particulars to draw the necessary diagrams, so that the reader may verify the accuracy of the results obtained, and thus form an opinion as to the merits of the designs.

For reasons which will be stated later, the arches have been designed without backing or filling, and the effect of the horizontal pressure of the gravel on the extrados of the arch ring has not been taken into consideration. As the term "arch" is applied to both the arch proper and the complete structure (which includes the gravel), the arch proper will be called the "arch ring," wherever confusion would be likely to arise.

The stresses have been calculated on the usual assumption that the stress curve on a cross-section is a straight line, and the maximum stress is obtained from the formula:—

$$f = \frac{Q}{t}\left(1 \pm \frac{6s}{t}\right)$$

where f = maximum stress in lb. per square foot.
Q = normal thrust on a close section in lb.
t = thickness of arch ring in feet.
s = distance between the line of pressure and the centre line, in feet.

The line of pressure, to avoid tension in the arch ring, is supposed to lie entirely between the two middle third lines, but it is certain that the arch ring would not fail in tension at a section unless the maximum compressive stress on that section exceeds the safe compressive stress. The results of experiments on blocks of concrete asymmetrically loaded would be interesting.

The chief difficulty in the design of the arch is, probably, the determination of the position of the line of pressure. It must be a link polygon for the system of loads, but an infinite number of such polygons may be drawn by varying the polar distance, which represents the horizontal thrust, or by making the link polygons pass through different points in the cross-section at the crown. Hence the system of loads is not sufficient to determine the position of the line of pressure. If the arch

*"Surveyor," London, England.

ring is hinged at the crown and springings, the problem is considerably simplified, but, for varying loads, the introduction of hinges would have the effect of weakening the arch.

It is necessary, therefore, to make certain assumptions and to experiment on models of arches designed according to those assumptions, in order to see how far they are justifiable. It appears that, whatever assumptions are adopted, the arch, called the "Ideal arch," is much stronger than a circular or semi-elliptic arch of the same dimensions.

First Assumption. The true line of pressure is that link polygon for the system of loads which deviates the least from the centre line of the arch ring. Arguments in favor of this assumption are wanting, and consequently the lines of pressure are not shown in the diagrams, but the stresses, if calculated, would be found to be only slightly in excess of those obtained according to the third assumption.

Second Assumption. It is assumed that no arch ring is stable for symmetrical loading unless the link polygon, which touches the extrados middle third at the

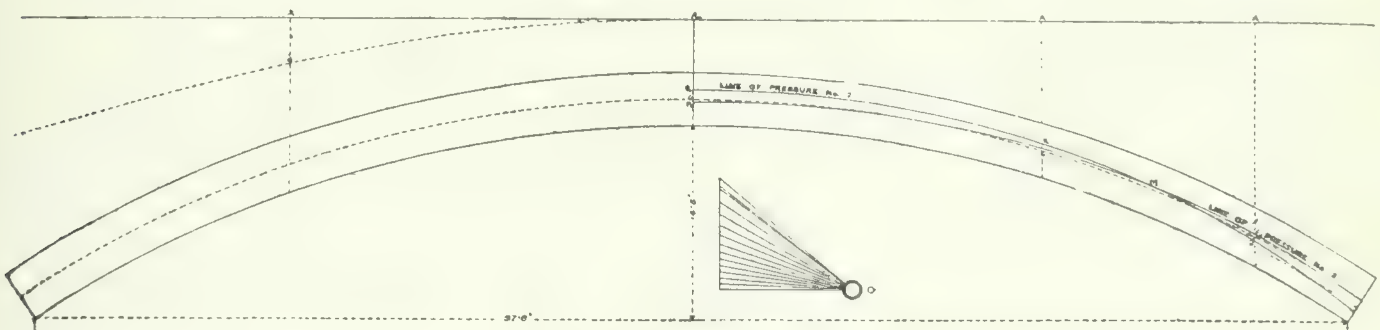


Fig. 1.—Circular Arch.

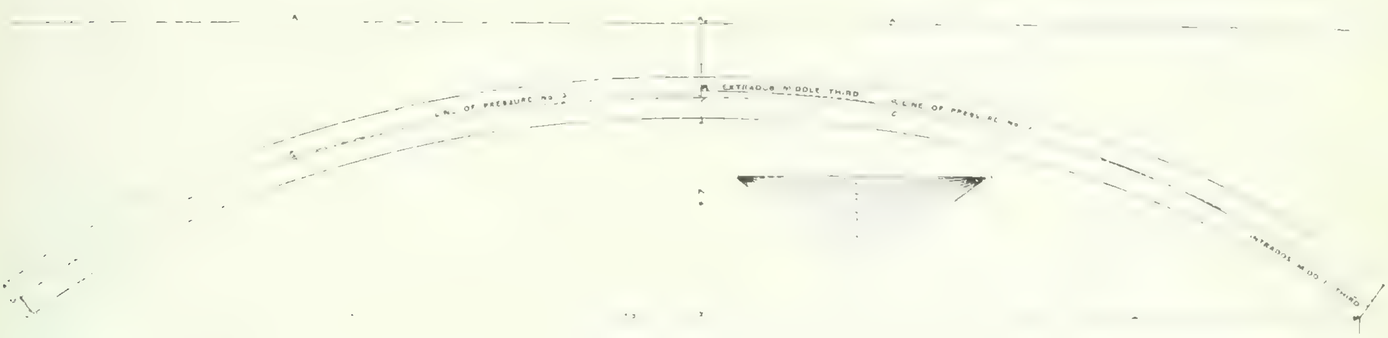


Fig. 2.—Ideal Arch. (Scales: Length, 12 ft. to the inch; load, 120,000 lbs. to the inch.)

Table I.—Illustrating the Advantages of the Ideal Arch Over the Circular Arch.

	Ideal Arch.	Circular Arch.
Span of centre line.........	100 ft.	100 ft.
Rise of centre line..........	15 ft.	15 ft.
Depth of gravel at crown....	4 ft.	4 ft.
Span of intrados	98.2 ft.	97.8 ft.
Rise of intrados	14.7 ft.	14.6 ft.
Thickness of arch ring......	3 ft.	4 ft.
Maximum compressive stress		
(*a*) Second assumption	76,300 lb.	The critical line of pressure cannot be drawn.
(*b*) Third assumption	40,500 lb.	40,500 lb.
Width of arch	20 ft.	20 ft.
Total quantity of gravel.....	17,720 cub. ft.	18,250 cub. ft.
Total quantity of material in arch ring	6,390 cub. ft.	8,450 cub. ft.
Total weight of arch........	2,971,000 lb. or 1,322 tons.	3,360,000 lb. or 1,500 tons.
Appearance	Pleasing, owing to gradually varying curvature.	Uniform curvature contrary to laws of beauty.

Some writers define the "Ideal arch" as the arch in which the centre line of the arch ring is the actual line of pressure for the given load. This evidently assumes that the centre line, if it is a link polygon for the system of loads, is the true line of pressure. Generalizing this, the first assumption may be stated as follows:—

crown, lies entirely between the two middle third lines between the crown and springings. In order that this condition should be satisfied, the horizontal thrust must not exceed the product of the radius of curvature of the extrados middle third at the crown and the total load on a section of the arch, 1 ft. wide, of which the cross-section at the crown is the central line. If H denotes the horizontal thrust, ρ the radius of curvature, g_o and t the depths of the gravel and arch ring at the crown, and w_l, w_g, w_a the respective weights of the live load, gravel, and material of the arch ring, then H must not exceed $\rho\ (w_l + g_o, w_g + tw_a)$. If such a line can be drawn it is evident that, by reducing the horizontal thrust, the line can be made either to touch the intrados middle third at or towards the springings, or to pass through the same middle third at the springings, and the line would then be the critical line or pressure.

Though the first signs of collapse in arches have appeared at points suggested by the critical line of pressure, it does not necessarily follow that the true line of pressure tended to approach that line of pressure previous to internal collapse. The apparent cause of failure is often different from the real cause, and the line of pressure may have taken up the position indicated by the critical line of pressure as a consequence of internal failure. Failure of the backing or insufficient depth of gravel at the crown would tend to concentrate the load

at the crown to a greater extent than at other sections during the passage of a live load.

This assumption is usually considered as the criterion of stability, but some arches, which have been standing for years without showing any signs of collapsing, do not satisfy the test.

Third Assumption.—The author is inclined to think that the true line of pressure follows the line of least resistance, which is the link polygon which gives the least stresses in the arch ring.

The assumption underlying this assumption is, that for comparatively low stresses, the resistance of concrete and masonry to compression increases with the stress. If the line of pressure deviates from the centre line, the maximum stress on a cross-section is thereby increased, and increases with the distance of the line of pressure from the centre line, in accordance with the formula previously given. Hence the resistance to compression tends to make the deviation of the line of pressure from the centre line as small as possible. The line of pressure, on the other hand, tends to rise at and near the point at which a load is applied and to fall at other points, so that it tends to deviate from the centre line at points where it previously coincided with that line. Equilibrium is established when the maximum stress at the extrados of one section is equal to the maximum stress at the intrados of another section, and equal or greater than the maximum stress at any other section. According to this assumption the Ideal arch is the arch in which the maximum stress at every cross-section is the same. This will be found to be an arch in which the centre line of the arch ring is a link polygon for the system of loads, but, for an arch ring of uniform thickness, the true line of pressure would not coincide with the centre line except at the springings, the stress there being uniform and the same at the extrados and intrados, and the same as at the extrados of every other section. Such an arch, if designed for the maximum load, would be strong enough to support a smaller load, though it would not be the Ideal arch for the decreased load.

The centre line of a circular arch is not a link polygon for the system of loads on an arch; hence the maximum stress at every cross-section will not be the same for any position of the line of pressure. The true line of pressure, however, takes up such a position that the maximum stress at the extrados of one cross-section is equal to the maximum stress at the springings, and greater than the maximum stress at any other cross-section.

The advantages of the Ideal arch over the circular arch are illustrated in Table I. and in the drawings, where it is shown that an Ideal arch 3 ft. thick is as strong as a circular arch 4 ft. thick.

The Backing or Filling.—It is usual in masonry arches to introduce a certain amount of backing or filling above the arch ring. If this is intended to give additional strength to the arch, it is unnecessary to design the arch ring to carry the additional load, which is the excess of the weight of the backing over the same number of cubic feet of gravel. If the intention is to increase the dead load in order to reduce, as far as possible, the variations in the stresses during the passage of a live load, the dead load should be increased at the crown, where the variations are likely to be greatest. If any backing is introduced, it should extend over the crown so as to form an arch, which would thus tend to distribute the load on the arch ring. A backing which does not extend over the crown acts like a cantilever, and, in case of failure in tension at any point, would tend to exert an excessive pressure at or near the crown.

Though, in the designs submitted, no backing has been introduced, the design of the Ideal arch may be easily adapted to arches with a certain amount of backing.

Horizontal Pressure on the Arch Ring.—According to theories on earth pressure, the vertical pressure at any point gives rise to a horizontal pressure, bearing a certain ratio to the vertical pressure. An inclined surface, such as the extrados of the arch ring, is thus subjected to a horizontal pressure. The resultant horizontal pressure, except in the case of very flat arches, acts below the centre of the cross-section at the crown, and would thus tend to lower the position of the line of pressure at that section. The effect is, however, small, and as the tendency is to strengthen the arch by counteracting the influence of the vertical load, it has not been taken into consideration in the designs.

Explanation of Diagrams.—The weight of gravel is taken as 110 lbs. per cubic foot, and the weight of the material of the arch ring as 160 lbs. per cubic foot. The depth of the gravel at the crown is 4 ft., but this is equivalent to a depth of gravel of 2 ft., and a uniformly distributed live load of 220 lbs. per square foot, or a depth of gravel of 3 ft. and a live load of 110 lbs. per square foot.

Circular Arch (Fig. 1).—On the right-hand side, the lines of pressure Nos. 2 and 3 have been drawn, in accordance with the second and third assumptions respectively, for a circular arch 4 ft. thick. The radius of the extrados middle third is 91.5 ft. and the total weight of a section of the arch, 1 ft. wide, at the crown is 1,080 lb.; hence the horizontal thrust for the line of pressure No. 2 must not exceed 98,820 lbs. This line of pressure cuts the intrados middle third towards the springings, so that the arch is unstable according to the second assumption. The link polygon, which touches the extrados middle third at the crown, and which passes through the intrados middle third at the springings, lies outside the extrados middle third near the crown, though this might not be apparent unless the figures are drawn to a large scale.

The line of pressure No. 3 cuts the cross-section at the crown just below the centre line. Between the crown and springings it cuts the centre line at two points, and lies for a part of the distance above the centre line. The maximum stress on the cross-section at the point M is about 40,500 lbs. per square foot, and is equal to the maximum stress at the springings and greater than the maximum stress on any other cross-section. Hence this line has been drawn in accordance with the third assumption.

The vector polygon has not been drawn for the line of pressure No. 3, but the pole is indicated by a small circle, the polar distance being greater than for line No. 2. On the left-hand side the dotted curve GA_0 indicates the surface of the gravel in a circular arch 4 ft. thick, which would make the centre line of the arch ring a link polygon for the system of loads. The load in this case is evidently much less than the actual load on an arch, and it is difficult to imagine that an arch is ever loaded in such a manner as to make a circular arch the ideal arch for the system of loads.

For a semi-circular or semi-elliptic arch, the centre line is a link polygon for a load which would be infinite at the springings, the load curve being as indicated in Fig. 3. This figure is drawn for a semi-circular arch, but the figure for a semi-elliptic arch would be similar. The load is represented by the vertical distance between the load curve and the centre line.

Ideal Arch (Fig. 2).—The same lines of pressure are drawn as for the circular arch, the line No. 2 being drawn

on the right-hand side and the line No. 3 on the left-hand side. Portions of the middle third lines are shown in dotted lines in this as well as in the circular arch. The line of pressure No. 2 lies entirely between the two middle third lines; hence the arch will not fail in tension. The line of pressure No. 3 lies a little above the centre line at the crown and between the crown and springings, and coincides with the same at the springings. The maximum stress at each section is found to be about 40,500 lbs. per square foot, and the line therefore satisfies the third assumption.

The diagrams may be drawn from Table II., the extrados and intrados being the curves which touch the circles drawn with their centres on the centre line and of diameter equal to the thickness of the arch ring. The centre line of the circular arch may be drawn with a beam compass, the radius being 90.83 ft., or from the ordinates given in the table:—

Notation.

x = distances on each side from the vertical line at the crown.
AC = ordinates of centre line.
AP_2 = ordinates of line of pressure No. 2.
AP_3 = ordinates of line of pressure No. 3.
AG = ordinates of line GA_0.
H_c = horizontal thrust for link polygon coinciding with centre line.
H_2 = horizontal thrust for line of pressure No. 2.
H_3 = horizontal thrust for line of pressure No. 3.
t = thickness of arch ring.

Table II.

Circular Arch.	Ideal Arch.
H_c = 98,090 lbs. [for gravel up to GA_0]	H_c = 97,500 lbs.
H_2 = 98,820 lbs.	H_2 = 90,200 lbs.
H_3 = 112,200 lbs.	H_3 = 96,720 lbs.
t = 4 ft.	t = 3 ft.

All distances measured in feet.

AG	AP	AP_3	AC	x	AC	AP	AP_2
0	[illegible].20	5.33	[illegible]	0	5.50	5.38	5
0.03	....	....	6.03	2	5.52	5.40	..
0.15	....	....	6.20	6	5.67	5.55	..
0.40	....	....	6.55	10	5.98	5.86	..
0.78	....	....	7.09	14	6.44	6.33	..
1.27	....	....	7.81	18	7.08	6.97	.
1.89	....	....	8.71	22	7.90	7.80	..
2.63	....	....	9.79	26	8.91	8.81	.
3.48	....	....	11.09	30	10.14	10.05	.
4.41	....	....	12.61	34	11.61	11.54	..
5.44	....	....	14.34	38	13.34	13.28	.
6.51	....	....	16.29	42	15.37	15.33	.
7.65	....	....	18.49	46	17.75	17.73	..
8.72	....	....	21.00	50	20.50	20.50	..
....	....	....	.....	54	23.69	.....	..

Though the remarks made in this article are intended to apply to masonry and concrete arches, most of the remarks are applicable to reinforced concrete arches as well, and it would evidently be an advantage to design such arches so that the centre line of the arch ring is a link polygon for the system of loads.

It is reported from Pittsburgh, Pa., that a process for extracting ferro alloys of manganese and silica from slag, which it is claimed will result in an immense saving to steel manufacturers, has been discovered by two students

SASKATCHEWAN WATER COMMISSION.

WE print below some extracts from the report of the Saskatchewan Water Commission which was read before the Legislature at the recent session, which report deals with the question of the feasibility of diverting water from the Saskatchewan River for domestic and industrial purposes throughout central and southern Saskatchewan. The report was presented by the Saskatchewan Water Commission, of which the Hon. Senator J. H. Ross and Mr. A. J. McPherson were members. With the assistance of several well-known engineers, the whole area to be supplied was thoroughly examined and definite knowledge has been secured as to the practicability or otherwise of the scheme. The whole question is one of extreme importance in that it vitally affects the future of two of the large cities in the province, as well as the rural population of a large and thickly settled region.

The area proposed to be served is bounded by lines running on the north along the Qu'Appelle River from Elbow to Lumsden, through Balgonie, Francis and Weyburn on the east, and from Truax, skirting the Dirt Hills to Mortlach and the hills south of Thunder Creek, to Log Valley on the Saskatchewan.

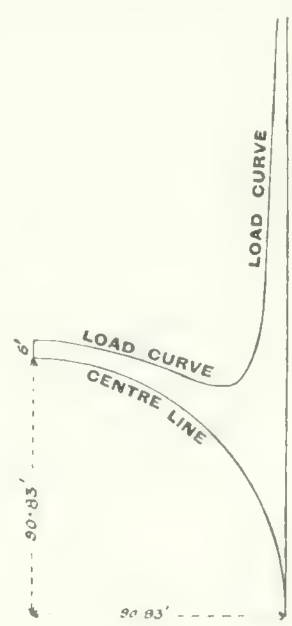
The water would have to be raised some 330 feet above the level of the Saskatchewan River and conveyed long distances with numerous pumping stations to where it would be used. The enormous expense of this can only be met if great quantities of water are used, and it is therefore necessary that the cities of Moose Jaw and Regina be included in the scheme unless its cost is to be prohibitive.

Over a large part of the area described above, water is scarce, no matter how deep wells are sunk, and there are stretches of country in which no water has been found, owing to the thickness of the clay deposit which is characteristic of most of the district. This means that many farmers have to haul water, often for great distances, during a part of each season.

Dealing with the present water supply for Moose Jaw, Mr. W. J. Francis, a consulting engineer of Montreal, states that after deducting the requirements of the railways, the city of Moose Jaw can only depend on about 400,000 gallons of water per day, or 20 gallons per capita

FIGURE 3

Design of Masonry and Concrete Arches



per day, which is a quite inadequate supply. If the future development of the city is not to be endangered a further supply must be found, but in Mr. Francis' opinion the local sources of supply are even now being fully utilized. The city of Regina is slightly better off, as the local sources of water supply have not yet been fully developed, and it is considered that enough for a city of 100,000 population could be secured.

One of the gravest features of the whole situation is the question of supplying the requirements of the railways. At the present time here and there along the railway lines tanks are supplied from dams built across ravines and small creeks to hold the water collected in these basins. This source of supply, however, can at best only be termed precarious. It is, of course, at the divisional points that the railway requirements are largest. It has been estimated that the trains passing through Regina alone require from 600,000 to 700,000 gallons per day. In addition, both at Moose Jaw and Regina there are machine and repair shops and round houses taking about 1,000,000 gallons per day at the two points. At Moose Jaw a dam across the Moose Jaw Creek gives a supply of water which would be only barely sufficient in a dry season, while at Regina a gravity pipe line from Pilot Butte supplies about 500,000 gallons per day, but this is about all the water which can be supplied from this source. It will thus be readily seen that if a dry season should come, and if at the same time there should be any extra pressure of business, the railways would be faced with very serious difficulty in obtaining adequate water supplies.

A suggested method of diverting the water is as follows: Install a pumping plant at the river, and pump to the top of the hill east of the river, a distance of about 5,500 feet. From this point the water could be conveyed in an open channel by gravity to the head of Thunder Creek, and thence down the Thunder Creek Valley by an open channel and in the creek to Pelican Lake. Construct a reservoir of a suitable size at the upper end of Pelican Lake, and from this pump the water, after filtering it through some 50,000 feet of pipe line, to join with the line leading from the head works reservoir of the Sandy Creek Moose Jaw water supply, to Moose Jaw. Construct an open channel from the Pelican Lake reservoir to join with Thunder Creek to Moose Jaw. About one mile near the outlet of this latter line from the Pelican Lake will have to be a closed gravity channel.

In order to insure that the city of Saskatoon will not suffer in any way from the diversion of this water, it is proposed to store sufficient water in the reservoir for winter use, as the effect of the withdrawal would be greatest at the period of minimum flow in January, February and March.

The financial side of the problem has also been carefully studied by the commissioners. In their opinion it is imperative that the scheme should be financed on the security of those interested in such a way that other interests, as their need arises, could be added to the system. An alternative scheme for the improvement of the water supply at Moose Jaw is suggested which would meet for the time being the requirements of the situation until the time arrives when this scheme in its entirety becomes a necessity.

The report concludes with the following paragraphs:

"The immediate difficulty is to devise such a system that the first cost will not be beyond the means of the interests involved nor the cost of the water prohibitive. It is questionable under present conditions if the sum of $850,000, which is the estimate for the initial construction by the cheapest method yet devised and reported on that will give the comparatively small quantity required at present is not beyond the abilities of those immediately interested to finance.

"The desirability of both the above modifications should be canvassed before exact plans for construction are prepared or construction undertaken, or before a decision is made that it is beyond the possibility of construction under the present conditions."

TRADE INQUIRIES.

The following inquiries relating to Canadian trade have been received by the Department of Trade and Commerce, Ottawa. The names of the firms making these inquiries, with their addresses, can be obtained only by those especially interested in the respective commodities upon application to: The Inquiries Branch, the Department of Trade and Commerce, Ottawa, or the Secretary of the Canadian Manufacturers' Association, Toronto, or the Secretary of the Board of Trade at London, Toronto, Hamilton, Kingston, Brandon, Halifax, Montreal, St. John, Sherbrooke, Vancouver, Victoria, Winnipeg, Edmonton, Calgary, Saskatoon, Chambre de Commerce de Montreal and Moncton, N.B. Please quote the reference number when requesting addresses.—

349. Pitprops.—A North of England firm of importers would like quotations per 72 lineal feet, c.i.f. Hull, on pitprops of the following dimensions: 3-inch top diameter, 3 to 9 feet long 3½-inch top diameter, 3½ to 9 feet long; 4-inch top diameter, 4 to 9 feet long; 4½-inch top diameter, 4½ to 9 feet long; 5-inch top diameter, 5 to 9 feet long; 5½-inch top diameter, 5½ to 9 feet long; 6-inch top diameter, 6 to 9 feet long; 6½ inch top diameter, 6½ to 9 feet long; 7-inch top diameter, 7 to 9 feet long.

362.—Steam-Electric Power Plant Apparatus and Engineering Specialties.—A gentleman who intends visiting New Zealand during the coming summer is desirous of securing the agencies of Canadian engineering manufacturers of steam-electric plant apparatus and engineering specialties, and is desirous of receiving full technical description of apparatus, together with illustrations, weight of apparatus, shipping weight, and weight of heaviest piece, and over-all dimensions. Present prices either f.o.b. Canadian or American port or c.i.f. New Zealand port.

370. Tungsten Ores.—A Liverpool firm of mineral and metal importers would be glad to receive offers from Canadian producers of tungsten ores, of which they seek supplies.

371. Asbestos Millboard.—A London firm desires the addresses of Canadian manufacturers of asbestos millboard.

387. Trade with India.—A large importing firm in India desires catalogues and wholesale price lists from Canadian manufacturers of hardware, implements, tools, plantation supplies, etc., as outlined on page 863 in Weekly Bulletin No. 638.

389. Agencies.—A Cape Town firm of commission agents, having a number of travellers on the road are prepared to take up Canadian agencies. Correspondence requested.

392. Calcium Carbide.—A London firm asks to be placed in touch with Canadian manufacturers of carbide of calcium with a view to shipment to Australia.

395. Foundry Requisites or Foundry Plant of any Kind. —A Glasgow firm would be glad to hear from Canadian firms making a specialty of above.

396. Haematite Iron Suitable for Malleable Castings.—A Glasgow firm is anxious to obtain supplies of above from Canada.

397. Heavy Steel Riveted Crane-Casting Ladles.—A Glasgow firm wishes to receive quotations, c.i.f. Glasgow, for eleven crane-casting ladles, steel riveted, each 50 tons and complete with double set of stopper gear; also a considerable quantity of steel mandril bars for drawbenches, the bars to be cut from 1½ to 2⅜ inches diameter by 30 feet long and to be machine straightened. The material for these bars must be of a hard and ductile quality as per following analysis:

Approximate analysis:—

Phosphorus	0.028
Sulphur	0.030
Silicon	0.203
Manganese	0.8
Combined carbon	0.6

THE NICK AND BREAK TEST IN THE INSPECTION OF STEEL RAILS.*

STEEL metallurgists will recall that prior to the general dependence upon the services of the analytical chemist, that is, in the days when but few steel works had their own laboratories, the grading of crucible steel in the ingot, and before it was drawn down into bars, was based upon the appearance of the fracture of each separate ingot. After the ingots became cold, a piece was broken off one corner and an expert workman judged of the hardness of the metal by the exposed fracture, and marked the ingot accordingly. Thus one would be used for tool, another for drill, another for spring steel, and so on.

In later years, when the dissatisfaction with the results given by steel rails led to much discussion as to what changes should be made in the specifications governing their manufacture, the Rail Committee of the American Railway Association called in consultation the late William Metcalf, Past-President of the American Institute of Mining Engineers, 1881; Past-President of the American Society of Civil Engineers, 1898-99, and for years a steel maker. Previous to that time drop tests of pieces of rail representing each heat of steel had been included in some of the specifications, but the object of such tests had been limited to determining the ductility of the steel. There had not been any prescribed breaking tests with a view of disclosing the internal structure of the rail.

Mr. Metcalf, based no doubt upon his experience as a maker of crucible steel, urged that the then current testing did not go far enough, and that several pieces of rail from each heat should be broken, and by the disclosed fractures the rails from that heat accepted or rejected. The committee, when reporting, did not adopt his suggestions, but, based largely upon his insistence that the drop testing as then conducted did not go far enough, many railroad engineers gradually enlarged the scope of their drop-testing requirements until it became the general practice to break, say, three pieces from each heat of open-hearth steel and to accept or reject certain rails according to whether or not interior defects were revealed. It was argued that the practice should be extended to include the breaking of a piece of rail from the top end of each ingot rolled, and in fact some experimental rollings were made under such provisions, but opposition to the plan of making this fracture test on a piece of rail from each ingot developed among rail makers, with the result that what seems to us to be a perfectly logical method of testing rails to insure against acceptance of defective material, failed to have a fair working trial; and thus it remained, about a year ago, for the Algoma Steel Corporation, whose mill is at Sault Ste. Marie, Ont., to open the door commercially, so to speak, to the possibilities of a specification for rails, marking, we believe, a distinct step forward in the direction of safer and better wearing rails.

A contract for 10,000 tons of rails made by the Canadian Pacific Railway with the Algoma company was the first to require what has been commonly termed "the nick and break test on each ingot," and this was quickly followed by others for rails to be shipped to United States under similar conditions of testing. In justice to the Algoma company it may be said that they have become so appreciative of the logic, as well as the economy, of the nick and break test that they have seen fit to have it incorporated freely and without extra compensation in many of their specifications.

By the nick and break test mentioned above is meant, firstly, the nicking; and secondly, the breaking, by some mechanical means, of a short length of rail selected as required by the specification. This, it will be noted, must be, for the first, or the original test, the top end of the top rail of each ingot rolled, and naturally for this sample, the crop end, which must be cut by the hot saws, from the top of the "A" rail was used. These crop ends were ordinarily from 18 ins. to 24 ins. long, and after being stamped with the heat and ingot number, to permit of identification, were allowed to cool for a little over thirty minutes, and were then quenched in water, pains being taken to insure quenching from a temperature color of near black or natural cold steel, so as to render no appreciable change in steel structure possible. Then the pieces were nicked as desired; and, for the purpose of breaking, inserted in a specially designed anvil of a bulldozer (Fig. 1) so arranged that the ram readily broke the rail where it had been nicked, giving, without trouble in most cases, the square character of fracture desired for examination. Thus the fractures were ready for judging

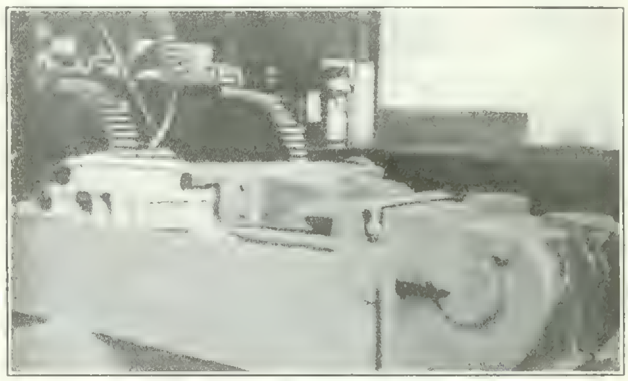


Fig. 1.—View of Bulldozer Used at Algoma Steel Works for Breaking Crop Ends of "A" Rails, Showing also the Quenching Tank.

in an average time of about one hour after the rails were rolled, and in many cases long before the actual drop test pieces were cold enough to test, and even before the rails represented had reached the cold straightening presses. It is interesting to observe that the bulldozer actually broke the rails at a rate of about three per minute, or at a rate, say, of 2,000 pieces in twelve hours; and, as each piece represented an ingot, the rate of breaking possible shows it to be well in excess of any probable tonnage that could be rolled with any present mill equipment. In case of the fracture on this original test showing bad, thus incurring the rejection of the top rail of the particular ingot represented, it was necessary to locate that rail in front of the straightening presses by identifying the heat and ingot number and rail letter on it, and from its bottom end to break a piece to represent the second rail of the same ingot. This requirement continued to all of the rails of the ingot as far as necessary, and it was found possible to accomplish the desired end easily. A little care in the distribution in front of the straightening presses of the rails from the hot beds made the identification possible without the necessity for extended searching, and when the particular rail for retest was located, it was marked and in due course taken to the nearest straightening press, where a piece readily was broken from its lower or back end and the fracture scrutinized by the inspector without

*Abstracted from the report of Robt. W. Hunt and C. W. Gennet, Jr., to the Rail Committee of the American Railway Engineering Association.

delay or trouble to the regular operation of the mill. In fact, no greater trouble arose with regard to locating and making the necessary retests than is demanded in any mill when all the top rails of a heat, or even a whole heat, have to be located and identified in order to comply with rejection requirements, a matter of more or less everyday occurrence in some mills.

Undeniably the judging of the fractures produced by the nick and break test is a matter of great importance, and requires the services of experienced and competent men; but so do all the detailed parts of intelligent and efficient rail inspection; in fact, the same statement can be truthfully made in regard to every detail of steel rail making. The trend of all matters pertaining to rails is indisputably toward obtaining a safer and better wearing product, railroad officials and manufacturers alike being more appreciative of conditions in this respect than ever before; this attitude, no doubt, being stimulated because of the activities of the different governmental and state commissions. Recent improvements in mill practice have been acknowledged, and it is equally true that railroads are taking greater pains than formerly with the maintenance of their tracks and equipment, and thus of greatly increased importance is the employment of experienced and competent inspectors with whom to entrust the duties of rail inspection. Any specification and any detail of inspection becomes a hardship to the manufacturer and wasted expenditure to the purchaser when inexperience and incapable inspectors are employed, and under such circumstances the nick and break test specification is of no greater assurance against accepting bad rails than it is against making bad steel.

THE BUILDING AND FINANCING OF SUBWAYS.*

FROM a careful analysis of increase in population in various cities, compared with the increase in street railway patronage, this increase is at a slightly higher rate per year than the square of the increase in population of the territory served.

As a result of the marked increase in patronage in such cities as New York, Philadelphia and Boston, a condition was reached on various highways where it was deemed impossible, or at least uneconomical to further increase the number of street cars per hour. There is some difference of opinion as to the exact point of saturation for surface car service. To analyze in detail this condition requires an assumption as to minimum headway between surface cars. Various estimates show that an interval of nine seconds between moving units on the street is consistent with safety. Assuming this fact and adding to it the estimated period of rest of seven seconds for a car, to permit of passengers boarding and leaving would result in cars passing a certain point at the rate of every sixteen seconds. Under these conditions a maximum speed of twelve miles per hour and an average speed of eight miles per hour can be maintained where the usual number of stops are made. This figure is probably correct for practical operation.

In the report to the Merchants' Association, of New York, by its Committee on Transportation and Engineering, 1903, it is stated: "With a time interval of sixteen seconds the number of cars that may be moved past a given point per hour is 225." The committee did not believe that on congested streets like Broadway, New York, a service of more than 220 cars per hour passing a point in any one direction could be reasonably expected under the most favorable circumstances likely to occur, but believed that this number per hour was a reasonable estimate of what should be done.

They further stated: "We are confirmed in this belief by our own observations of what is being done at this time in Boston, and the large number of headway observations on Broadway at Chambers and at Houston Streets appear to practically confirm the above conditions."

Experience in Boston partially confirms the opinion of the Commission, for previous to the opening of the Washington Street tunnel it was believed that a point of saturation had been reached, at which time there were operated between two points on Washington Street a maximum of 213 cars per hour in each direction. Previous to the opening of the Boylston Street subway in Boston as high a number as 260 cars per hour were operated in one direction over a very short section of a certain line on a special occasion, but this was made possible by part of the service operating in the Tremont Street subway and around the Park Street station loop.

The Public Service Commission for the First District of New York, April 17th, 1908, ordered "a minimum number of 25 cars in one direction in each fifteen-minute period on certain sections of Broadway." This would be at the rate of one car every thirty-six seconds, and it is believed by some that this is the lowest headway consistent with reasonably rapid movement of cars when all conditions are considered, such as vehicular interference, line intersections, joint usage of certain stretches of track, etc. Further, this thirty-six second headway is exceeded on some lines in New York on certain short stretches of track, where they operate from two to three times as many cars as are required for a thirty-six second headway.

There should be kept clearly in mind also in the study of maximum capacity of surface lines the difference between maximum number of cars that it is possible to operate and the speed consistent with good service.

In view of the above it is fair to assume, therefore, that when street car service for short stretches of track has reached a number slightly in excess of 200 cars per hour capacity the capacity on this stretch of track might be said to have reached a saturation point after which additional arteries must be utilized or other transportation facilities provided. Of course, this figure is also governed by the width and alignment of streets, as well as the size of the units and general traffic conditions.

Very often the saturation point of surface tracks is not the governing feature in added facilities, for necessity for such additional arteries is due to the demands of the public or public authorities for a more expeditious and convenient means of travel. Regardless, therefore, of the cause of providing high speed transportation facilities in the congested districts, there is no question but what the construction of same is unavoidable for one reason or the other.

When tracks on a certain street have reached the saturation point, whatever that may be, and additional transportation facilities must be provided, every conceivable effort should be made to use parallel streets for additional surface tracks, or even build an elevated structure. It is absolute economic waste to recklessly spend enormous sums of money for subway construction merely

*Paper prepared for the mid-year meeting of the American Electric Railway Association at Chicago, February, 1916.

because a particular highway has operating upon it all the surface cars consistent with either good transportation, or economy and subway construction should only be decided upon after other and less expensive means of furnishing additional transportation have been sufficiently studied to justify their inexpediency.

The enormous amount of traffic absolutely necessary to support expensive subway construction makes it incumbent upon those responsible for such expenditures to thoroughly satisfy themselves that the traffic offered and the conditions prevailing compel subway construction rather than the use of other arteries on the highway, or even private right-of-way construction on the surface.

From the commencement of operation of surface car service over a specific stretch of track, up to the time when such track is completely saturated with cars, the interest charges for the investment on this particular stretch of roadbed per passenger decreases as passengers and riding over same increase, and, therefore, up to the point of saturation, or up to the point when the total capacity of the roadbed is availed of, the greater number of passengers, the less expense for fixed charges per passenger.

On several properties in the United States there have been constructed high-speed underground thoroughfares, either as result of surface tracks having reached a point of saturation or as result of the demand of the public for more expeditious transportation. Immediately upon such construction taking place the fixed charges per passenger jump entirely out of proportion to what they were at the moment of surface track saturation, and ordinarily due to the nature of construction of the subway where it is necessary to build the same cross-section for a one-car train on fifteen minute headway, as is required for a 10-car train on a minute and a half headway, the fixed charges per passenger carried are entirely out of proportion to the ultimate capacity of the subway.

A marked example of the enormous investment necessary for construction of a subway is that of the Washington Street tunnel in Boston, built in 1908. The surface car tracks over the highway under which the Washington Street tunnel was constructed for a distance of approximately one mile represent an investment of approximately $253,000, while the tunnel cost approximately nine and a half million dollars, which, by the way, so far as we are able to learn, is the most expensive mile of roadbed and track in the world, not excepting the Jungfrau Tunnel in Switzerland.

In other words, the transportation companies building or leasing subways have been compelled to meet the enormous fixed charge for comparatively small patronage and pay the same rent or interest, whether the demands of traffic require the operation of a few cars per hour or the maximum capacity of the subway.

In certain instances there has been no substantial increase in rate of patronage where rapid transit service has become necessary. That is, the rate of increase of passengers carried per annum is not materially changed upon the inauguration of rapid transit service.

Generally speaking, it is granted that the cost of operation per passenger capacity with trains in a subway is materially less than electric car service on the highway, but unless the load factor is such as to give an opportunity for use of a reasonable capacity of the subway throughout a large percentage of the twenty-four hours, the fixed charges per passenger considerably more than offset the reduction in operating expense per car passenger capacity.

The original basis of establishment of rate of fare was entirely without regard to enormous subway investments, with a right-of-way furnished by the community, and if as result of entirely changed conditions, such as the outgrowing of the highway capacity or the pressure of the community, it becomes necessary to construct expensive underground thoroughfares, then either the rate of fare must be changed to meet these changed conditions or the community as a whole, benefited as result of such subway must bear, in a measure at least, proportionately to the indirect benefits accruing, a certain portion of the fixed charges until such time, if ever, as the ultimate capacity of the tunnel is reached and the load factor more nearly approaches 100 per cent.

There can be no question of the equity of such an arrangement, for it has been established without question that upon the construction of the subway the complexion of the community served radically changes, property values increase, particularly in the outlying district, and rents are correspondingly raised by landlords.

There is no reason, therefore, why the patron renting a home in the community benefited should pay an increased rate of fare and at the same time pay increased rental for his home as a result of the landlord's values having been increased by the subway construction.

The effect upon capital of companies who are endeavoring to furnish adequate transportation facilities, and who are required to pay interest or rentals on enormous investments entirely out of proportion to revenue received, can be readily concluded, and the consistency of the arguments, as well as their equity, compel recognition to the extent that where investments of this character become necessary the community as a whole must be compelled to participate in the support of same. This has been well evidenced by the case in New York, where in the construction of the latest subways the city of New York contributes in part towards the investment and fixed charges until such time as the net earnings resulting from the operation of the subway permit, after proper charges of every character, including operation, depreciation, etc., of the company bearing same.

The construction of subways, which are nothing more nor less than public highways, differs from other similar public improvements, such as surface highways, sewers, water systems, park systems, etc., in that instead of being constructed from time to time in proportion to the degree to which its capacity is to be used it is necessary, due to the physical nature of tunnels to build them substantially as large and at as great an expense in the first instance as is necessary to provide for not only the immediate requirements, but for the requirements of several years in the future. In other words, State highways, Metropolitan waterworks, sewerage systems, State parks, etc., are built and added to from time to time, and the ability of the community to digest same governs very largely the rapidity with which such systems are enlarged. In the case of a subway, however, it costs so much per running foot to construct, and a cross-section is just as expensive construction for a one-car train run once an hour as for a ten-car train run on a minute and a half headway, or its ultimate use.

It is thoroughly unfair, therefore, that a street railway company should be called upon to pay the entire interest on such an investment when the demands of the traffic and the amount of business available requires at the moment only a small proportion of the total available capacity.

In view of the marked increase in land values and general benefit to the community as a whole as result of subway construction it would seem equitable that those property owners who so materially benefit should contribute in some proportion toward the fixed charges for such improvement. In contradistinction of this, if the unit of fare was increased the tenants of the buildings in the territory involved would not only pay, as result of the subway, increased fare, but also increased rent, while the property owner would receive all of the benefits without participating in the expense.

It is entirely fair and proper that the community should have improved rapid transit facilities and thoroughfares just as rapidly as they are willing to equitably digest it.

In concluding, therefore, when the conditions on a certain highway have reached such a point that additional transportation facilities are necessary, there should first be an effort made to utilize parallel highways with surface tracks at a reasonable and proper investment consistent with the traffic offered. If this for proper reasons is dismissed there should then be effort made to construct surface tracks on private land or elevated tracks on either private land or the highway. If for good and proper reasons these other means are dismissed there is but one alternative left, and that is the construction of subways.

In other words, every conceivable effort should be made to provide additional transportation facilities at as low an investment as is consistent with the demands and the traffic offered, and the construction of subways should be only entered into after the most careful, thorough and conservative study and consideration of other means of furnishing transportation and with a full knowledge of the seriousness of burdening the community with tremendous investment and correspondingly large fixed charges.

If, therefore, it is finally concluded with a perfectly clear perception of what the financial results would be that subway construction is necessary it would seem fair that in the first place the Municipality, Metropolitan District or State should finance same, as undoubtedly money can be raised at a lower rate of interest than where such financing is done by private owners; and secondly, the community as a whole should participate with the company and riding public in the payment of interest charges.

More specifically, upon the completion of subways or tunnels built by the community, they should be leased to the transportation company serving that community on a sliding scale, charging such company rental in proportion to the relation of the capacity used to the total capacity. By such an absolutely fair and equitable arrangement the movement for subway construction automatically regulates itself in a fair and equitable manner to all interests.

There are approximately 82,530 deaths annually in the United States due to accidents, and in connection with the carrying on of dangerous industries there are 25,000 deaths and 700,000 injuries involving a disability of longer than four weeks.

Stellite is not steel, it contains neither iron nor carbon, but is a tungsten. It is entirely unaffected by any degree of heat that can be generated by cutting, and, it is claimed, will maintain its edge at speeds which no high-speed steel can stand, as well as be used on materials which high-speed steel will not cut. Stellite must be held in a tool holder, as it is of a brittle nature.

SLAG PORTLAND CEMENT.

In a paper on "Portland Cement" recently read by B. J. Day, M.I.Mech.E., before the Institution of Engineers and Shipbuilders in Scotland, some particulars were given regarding cement of which blast furnace slag forms one of the ingredients. Mr. Day, although recognizing that slag Portland cement is not as good as the best Portland cement, and hence does not command quite such a high price, yet is evidently in favor of its manufacture, and for several reasons. He states that, though it is true that it does not comply strictly with the British Standard Specification for Portland Cement, it nevertheless, if manufactured with care in accordance with the most up-to-date process, may be made to approximate very closely to it. As reasons why the manufacture should be proceeded with, Mr. Day shows first that the slag is in the ordinary course of events a waste product which costs in some cases a considerable sum annually to dispose of; secondly, that where the gases of the blast furnaces are available the cost of the power required to make the cement is a negligible quantity; and, thirdly, that in any case, owing to the fact that the lime in the slag occurs as oxide and not as a carbonate, as in chalk and limestone, less fuel is required in the kiln. According to him a plant producing 1,000 tons of cement per week would require 250 tons of coal less to produce that quantity if the cement were made with slag than it would if the raw materials were limestone and clay.

It is not all slags, however, which can be satisfactorily used to produce cement. Mr. Day gives some typical analyses of slags, as follows:—

	(1)	(2)	(3)	(4)	(5)
SiO_2	30.00	30.72	32.51	32.90	31.5
Al_2O_3	28.00	16.40	13.91	13.25	18.58
Fe_2O_3	0.75	0.43	0.48	0.46	.....
CaO	32.75	48.59	44.75	47.30	42.22
MgO	5.25	1.28	2.20	1.37	3.18
CaS	1.90	2.16	4.90	3.42	.....

It will be observed that the composition of these five samples of slags varies pretty considerably. The variation as concerns silica is not great, but the alumina content varies between 13.25 and 28.0, that is to say, there is more than twice the quantity in No. 1 that there is in No. 4. Then, again, there is considerable variation in the CaO figures, from 32.75 to 48.59 in the two extreme cases, the difference being thus nearly 50 per cent. Slags Nos. 2, 3 and 4 would be suitable for use in cement manufacture, whilst Nos. 1 and 5 would not be so suitable. The composition of the slag naturally varies with the composition of the ore, and the slags from some ores will not produce good cement. It is to this cause that certain failures of the past are attributed. Sufficient care was not exercised in ascertaining whether or not the slag possessed the requisite qualities for the purpose to which it was proposed to put it.

Mr. Day explains that, in order to treat blast-furnace slags, they should first of all be granulated. The effect of doing this is to cause the material to split up into fine sand-like particles; and to remove a large percentage of the sulphur and increase the hydraulic properties of the material. The ground slag is mixed with limestone in the correct proportion, the mixture being then ground and burnt in a kiln, the resulting clinker being in its turn ground to form the cement. The greatest care must, of course, be taken in getting the proportions right. All Portland cement manufacturers are aware of the vital importance of correct mixtures when using other raw

materials, and it is the same when using slag, and it is there that the trouble of the varying composition of the slag comes in. Still, with reasonable care and a competent chemist, this difficulty need not be insurmountable. There is, however, in addition, the mechanical difficulty that slag cement clinker is particularly hard to grind satisfactorily, and failure to appreciate that fact has been the cause of much trouble. Still, with adequate grinding plant the grinding can be effectively carried out. Then, again, slag Portland cement, owing possibly, remarks Mr. Day, to its high alumina content, is naturally very quick in setting. This, however, can be readily adjusted by known means, so that any specified setting time can be obtained.

The following table shows in what way slag Portland cement is not in accordance with the British Standard Specification, and how it compares in its properties with cement produced from limestone and clay.

	British Standard Specification for Portland cement.	Aberthaw "Druid" brand Portland cement	Slag Portland cement.
Neat Tensile (a) 7 days ...	450 lb.	644 lb. sq. in.	623 lb. sq. in.
Neat Tensile (b) 28 days...	$a + \frac{40,000}{a}$ or, say, 539	783 ,,	729 ,,
Sand (c) 7 days ...	250	283 ,,	207 ,,
Sand (d) 28 days....	$c + \frac{10,000}{c}$ or 290	382 ,,	280 ,,
Specific gravity ...	Not less than 3.1	3.203	2.96
Expansion	Not to exceed 10 mm.	.66 mm.	1.5 mm.

It will be seen that whereas the slag cement has a plentiful margin in excess of the standard requirements as regards neat briquette tests, both at 7 and 28 days, the strength of the sand briquettes is not equal to standard requirements. The 28-day test, however, is not greatly below the standard figure and the rise in strength between 7 and 28 days is greater than is expressed by the formula $c + \frac{10,000}{c}$. It will be noticed, too, that the specific gravity is low.

Slag Portland cement is usually manufactured on the dry or semi-dry system, but Mr. Day, in conjunction with some clients, is carrying out some experiments with a view to manufacturing on the wet system. So far, we gather, these experiments give promise of success. Mr. Day strongly recommends blast-furnace owners to consider seriously the question of turning their slag into cement.

In the discussion following the paper it was pointed out by a speaker that the sulphur in blast-furnace slag would disintegrate the cement and therefore it would be necessary to take very great pains in removing the free sulphur from the slag. For reinforced work the use of slag cement would be very dangerous. Other speakers mentioned cases in which slag cement had been successfully used. It appears that with very efficient inspection and proper tests of each shipment, and the storage of the cement until the laboratory results are known, that slag cement for certain uses is economical and efficient, employing as it does a product which otherwise is more or less wasted.

In proceedings by one railroad company in United States to condemn for railroad purposes the land of another, the Pennsylvania Supreme Court holds that the fact that the latter had ceased to operate did not limit the damages to the value of the ground for agricultural purposes, but permitted recovery on the basis of its value by reason of its availability for the location of a railroad.

STANDARD FORM FOR CONCRETE ROADS.*

THIS form is for the concrete pavement only. Cost of other items, such as grading, drainage, bridges, culverts, railings, etc., should be kept separately.

In consideration of the items mentioned, a division should be made indicating those portions of the highway improvement which can be considered as permanent as differentiated from portions which will need renewal in the course of time. Such a distinction is necessary in order to work out any reasonable system of highway financing.

Name and Location of Road........................
Length .... Width ...... Thickness ....
Proportions of Mix......Number of Cubic Yards......

		Per Cu. Yd.
1. *Labor:		
On subgrade..........	$..	
On forms........	......	
Material to mixer..............	......	
Mixer to place.................	......	
Covering and cleaning.........	......	
Total labor..............		$......
2. Concrete Materials:		
Cement, f.o.b...........	$....	
Hauling	.	
Storage	....	
Lost sacks and waste.	...	
Sand, f.o.b..............	...	
Unloading	...	
Hauling	.	
Stone, f.o.b. or in bins........	...	
Unloading	...	
Hauling	..	
Total concrete materials........		$.....
3. Water:		
Charge for..................	$..	
Piping	.	
Pump	..	
Labor, etc.....................	....	
Total water.....................		$.....
5. Plant for forms (interest and depreciation).		....
6. Reinforcement		.....
7. Joints		.
Total cost concrete pavement.......		$......

WAGE SCALE.

Superintendent ......Teams ......Common labor......
Assistant superintendent.......Auto trucks............
Skilled labor..........Length of working day.........

(Remarks on features of plant and materials which have special bearing on costs.)

* Includes supervision.

It will be noted that the form calls for reporting the cost on a cubic yard and not on a square-yard basis. The latter has been a popular method of reporting city paving costs, but the former is probably now the prevailing practice on concrete road work. The cubic yard system has the disadvantage of preventing ready comparison with the costs of other types, but possesses other advantages which, in the committee's judgment, more than counterbalance the disadvantage. The square-yard basis, on the other hand, is not definite, for it neglects the thickness of pavement, making comparison between two concrete slabs of different thicknesses difficult. The cubic-yard basis is not open to this objection. The cubic-yard method of reporting gives repeated checks on the amount of stone and aggregate used and on the thickness of pavement itself.

*From report of Committee to National Conference on Concrete Road Building.

TESTS OF EFFECT OF METHOD OF BEDDING UPON THE SUPPORTING STRENGTH OF DRAIN TILE AND SEWER PIPE.*

By N. J. Schlick,
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Iowa State College

TESTS were made on 24-in. pipe, with the types of bedding indicated by the accompanying diagram. The general method of procedure was to bed the pipe in the various ways and then to ascertain their actual supporting strength by applying load through standard upper sand bearing. A hydraulic jack suspended from a beam anchored to two large concrete blocks was used for the loading, the amount of the jack load being indicated on a gauge attached to the pump which operated the jack.

The test pipe was laid in a trench dug in made soil. The top soil was a rather close black loam and the subsoil a firm yellow clay. The location chosen for the tests of pipe in earth beddings was such that only the lower portion of each pipe was in clay. In all cases of earth bedding the filling material was loose top soil.

The work was done with labor unskilled in pipe laying. For this reason, and also to insure uniformity in the manner of bedding, the specified dimensions of the trenches and concrete cradles were adhered to somewhat more closely than they probably would be in a drainage practice. Aside from the care taken to insure uniformity the quality of the work was much the same as might reasonably be obtained in any drainage district.

The pipe used were selected at the factory primarily for uniformity. They were evenly burned and were free from structural defects. The concrete used in the concrete beddings was made with gravel from the pit on the campus. This gravel is not an exceptionally high grade and is probably no better than the average which would be used for this purpose over the State. It was screened and then remixed so that 50 per cent. would pass a ¼-in. screen. Two grades of concrete were used, grade A, a 1 : 5, and grade B, a 1 : 8 mixture of Portland cement and the remixed gravel.

The tests were made when the concrete beddings were approximately one month old. Classes 4-A, 4-B and 8 were the last put in, so that, because of a slightly shorter time of setting and considerably cooler weather, the concrete did not obtain as great strength as that in the other types of concrete cradles.

The concrete cradles, except those of class 7, were all constructed with the concrete at the sides carried up to a height equal to one-fourth the inside diameter of the pipe above the mid height. In the earth beddings the side filling was carried up to a little above the mid height of the pipe. In each case this allowed the use of the standard upper sand bearing over 90° of the pipe circumference.

The types of bedding tested might be divided into three general classes, namely, earth beddings, concrete beddings for firm soils and concrete beddings for yielding soils. This division can not be adhered to rigidly as some types of bedding might be used in any soil stable enough to prevent the pipe from settling. This is particularly true of class 7, which was patterned after a concrete bedding tested out by the Philadelphia Board of Public Works.

*Extract from a paper read at the meeting of the Iowa Drainage Association.

The first of the earth beddings, class 1, was made in accordance with the "Ordinary" method described in the "Standard Specifications for Drain Tile" of the American Society for Testing Materials except that the pipe were only bedded to a little above the mid height. The trench was shaped in the bottom to approximately fit the lower 90° of the pipe and the ditch filling shovelled in without tamping. There was quite a wide range in the supporting strength of these pipe, but the average agreed quite closely with the average strength as shown by standard strength tests with sand bearings. Because of this close agreement the average supporting strength of class 1 is taken as a basis for comparing the strengths developed by the other types of bedding.

The second class of bedding was the "First Class" method described in the standard specifications mentioned above. The trench bottom was sloped more accurately and was covered with 1 in. to 2 ins. of loose top soil before the pipe were laid. The filling was carefully tamped in, especially at the lower ⅛ points, up to a little above the mid height. The average strength of this class was 28% greater than that of class 1 and there was considerably less variation in the results from the individual specimens.

In the other type of earth bedding, class 9, the pipe were laid in a flat-bottomed trench and the spaces between

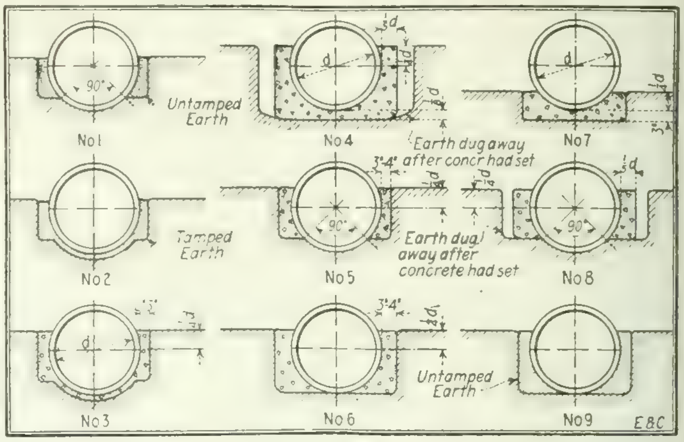

Diagram Showing Nine Methods of Bedding Drain Tile in Testing Supporting Power.

the pipe and the sides of the trench shovelled full of loose earth. No especial care was taken to see that the spaces between the bottom of the trench and the pipe were filled, and examination after the test showed that the filling there was so loose as to give the pipe no support. The average strength of these pipe was 26 per cent. greater than those of class 1. This increase in strength is thought to be due to the frozen condition of the ditch filling material at the sides of the pipe at the time the tests were made. There is reason to believe that this type of bedding will usually give lower strengths than class 1.

The results of these tests of pipe in earth beddings bring out two especially interesting facts. First: The strength of the pipe laid in the "Ordinary" method agreed very closely with that shown by standard strength tests of similar pipe, and second, that an increase in strength of 25 per cent. can be obtained by more careful bedding, as is specified for "First Class" pipe laying. This latter fact is especially noteworthy as in many cases the value of the 25 per cent. increase in supporting strength will be much greater than the extra cost of construction, including the salary of an inspector.

None of the pipe in earth beddings would support a larger load than that at which they cracked. All of the

tests indicated very clearly that the supporting strength of the pipe after cracking depended upon the bearing power of the soil at the sides of the trench. The soil in which these tests were made was probably more firm than the average in drainage work so that the values of the supporting strength after cracking are valuable for comparing with each other rather than for indicating what may be expected in other places.

The pipe laid in concrete cradles as specified in the standard specifications for "Concrete Cradles" for "Solid Soils" were tested as class 3. The concrete used was proportioned 1:8, as mentioned above. The bottom of the trench was shaped to fit the lower 90° of the pipe and 2 ins. of concrete placed on it. The space between the sides of the trench and the pipe, about 2½ ins. at the mid height of the pipe, was then spaded full of concrete up to a height of one-fourth the nominal diameter of the pipe above the mid height. These pipe had an average cracking strength 64 per cent. greater than those of class 1.

Class 5 beddings were a combination of the earth beddings and the concrete cradle just described. The bottom of the trench was shaped to fit the lower quarter of the circumference of the pipe and the spaces between the pipe and the sides of the trench, about 3 ins., filled with 1:8 concrete. These pipe showed a cracking strength of 46 per cent. greater than those of class 1.

The third class of concrete bedding for solid or firm soils was class 6. The trench was dug with a flat bottom and was about 6 ins. to 8 ins. wider than the outside diameter of the pipe. The pipe was laid in the trench and concrete poured in at the sides, care being taken to get the concrete well around the pipe. Tests of this type of bedding were made with two grades of concrete. In class 6-A a 1:5 mixture was used and in class 6-B a 1:8 proportion. The pipe of class 6-A supported a load 96 per cent greater than class 1 before cracking. Those of class 6-B developed a cracking strength 80 per cent. greater than that of class 1.

It is not certain that the tests determined the maximum supporting strength of the pipe of these three classes as the limit of the apparatus was reached on several occasions. When a large load was left on a cracked pipe for any considerable time, the uneven settlement caused derangements in the best apparatus. However, the maximum loads recorded were very large, the average being more than twice those supported by the pipe in earth beddings.

The tests of these classes also indicated that the supporting strength of a pipe after cracking depends upon the bearing power of the soil. For example, the average maximum loads supported by the pipe of class 6-B was greater than that of the pipe of class 6-A. These two classes were the same except that the concrete used in class 6-B was a leaner mixture than that used in class 6-A. The yielding of the lateral support was a gradual one. These tests all indicated that if the maximum applied load could have been held for a longer time, all the pipe would have collapsed.

The pipe of these three classes showed a marked tendency to develop side cracks at or near the top of the concrete at the sides. Where the side cracks in the pipe were below the top of the concrete it usually cracked opposite the crack in the pipe. In each case in class 3, the concrete was cracked along the centre-line at the bottom, the crack appearing simultaneously with the crack in the bottom of the pipe. In a great many cases the cradle was cracked near the lower ⅛ points by the continued application of pressure after the pipe had cracked.

The pipe all cracked at the top at the same or less load than at the bottom. In general, the development of a single crack at the top was indicated by a slight decrease in the indicated load, and the appearance of cracks in both top and bottom by a marked decrease in the indicated load. The side cracks usually developed while the load was being again raised to that at which caused the cracks in the top or top and bottom.

The bedding designated as class 7 was patterned after the Philadelphia method. This type of bedding or cradle would be equally effective in all soils firm enough to allow of the construction. The trench was dug a little wider than the outside diameter of the pipe and the bottom left flat. About 3 ins. of 1:8 concrete was placed the full width of the trench and the pipe laid upon it. Concrete was then placed around the pipe to a height of 6 ins. or one-fourth the inside diameter, above the bottom of the pipe. This bedded the pipe in concrete for a little over 90° but furnished no side support whatever, as the top of the concrete was just about even with the surface of the ground.

The pipe of this class showed an average strength before cracking 82 per cent. larger than those of class 1. As these pipe received no side support, they collapsed as soon as the main fractures were developed. These pipe all cracked at the top at the same time, or before, they did at other points. In no case did one of these pipe crack through the portion bedded in the concrete. The general failure was at the top and at the sides at the top of the concrete. Some pipe also cracked at one ¼ point at the side but in no case at both sides ¼ points.

An examination after the tested pipe were removed from the concrete showed that each of the concrete cradle was free from cracks. It may be that as great a supporting strength can be produced in the pipe with a lighter cradle of this type. This type of cradle is easier to construct and required less concrete than some of the other types in which the pipe had no greater supporting strengths.

As it was impossible to secure soils which would reproduce the conditions met with in work in what are termed yielding soils, a condition which was more severe was provided. After the concrete in the cradles had set, the earth was dug away at the sides down to the bottom of the concrete. This method gave the pipe no side support except that furnished by the concrete cradle.

Tests were made of pipe bedded in "Concrete Cradles" for "Yielding Soils" as specified in the "Standard Specifications for Drain Tile." In class 4-A a 1:5 concrete was used and in class 4-B 1:8 concrete.

The trench was dug 10 ins. wider than the outside diameter of the pipe and with a flat bottom. A 3-in. layer of concrete was placed in the trench and the pipe laid upon it. Concrete was then poured in at the sides up to the specified height of ¼ the inside diameter above the mid height.

The pipe of class 4-A showed an average strength before cracking 38 per cent. larger than those of class 1, while those of class 4-B supported 50 per cent. more load before cracking than did those of class 1. The fact that the cradle of the leaner concrete gave the larger support is attributed to the fact that the pipe of class 4-B were laid before those of class 4-A and that cool weather and frosty nights prevailed after the cradle of class 4-A were poured.

The pipe of these two classes usually cracked at or near the four ¼ points at the same time, though the side cracks were often at or near the top of the concrete. In

all cases the concrete cradle cracked along the centre line in the bottom, and often at about the lower ¼ points of the pipe, at the same time the pipe developed fractures. After the cradles were cracked in the bottom, the two sections revolved around the lower outside edges and the pipe would support practically no load.

The bedding of class 8 were very similar to the combined earth and concrete bedding of class 5, except that the earth was dug away from the outside of the concrete so as to reproduce as nearly as possible the conditions prevailing when this type of bedding is used in yielding soils.

The concrete used in these beddings was proportioned 1 : 9. It was poured in cool weather and had developed only a comparatively small portion of its final strength at the time the tests were made.

The pipe of this class had an average supporting strength only 18 per cent. larger than those of class 1. The concrete received no side support so that the load which developed the cracks in the pipe was the maximum. These tests indicated that this type of bedding would give but little side support other than that due to distributing the pressure over a larger area. In many soils this would result in a noticeable increase in supporting strength but in very wet soils the increase would be small.

The class of bedding still to be tested will be of the same general type as class 4, which is the "Concrete Cradle" for "Yielding Soils" of the "Standard Specifications for Drain Tile." The cradles of class 4 were made with the minimum dimensions specified, while the new type will be designed to safely support a 24-in. tile when cracked at the four ¼ points and receiving the estimated maximum load from ditch filling.

The data given above are from only one series of tests and can not be taken as final until they are verified by further work. There are, however, some very important general facts which are pretty definitely shown.

These results might be summarized in three general statements, as follows:—

1. The supporting strength of tile laid in the "Ordinary" method is practically the same as the "Ordinary Supporting Strength" shown by the standard tests.

2. The supporting strength can be increased 25 per cent. by more careful earth bedding and 80 per cent. or 90 per cent. by the use of concrete cradles.

3. The supporting strength after the pipe is cracked depends upon the bearing power of the soil at the sides of trenches, irrespective of the type of the bedding.

A SUBSTITUTE FOR PLATINUM.

An alloy for use in contact and spark devices to replace platinum has been patented by Mr. Paul R. Heyl, of New Rochelle, N.Y. (assigned to Commercial Research Co., of New York City). This alloy consists of silver and palladium, in varying proportions according to the conditions under which it is to be used. An alloy of silver with 2 per cent. of palladium has been found to give satisfactory results under many circumstances. When the contacts or spark points are exposed to sulphur compounds, 5 per cent. or more of palladium should be used. The alloy which was found to give the greatest resistance to spark erosion was that of 60 per cent. palladium and 40 per cent. silver. Additions of palladium to silver raise the melting point and lower the thermal conductivity. It has been found that, on account of the high thermal conductivity of silver, the heat from the spark will be conducted away fast enough to prevent melting of the silver. In view of this fact, silver-palladium alloys with very high percentages of silver can be used in a great many cases.

SHIPBUILDING IN CANADA

The Cunard Steamship Company recently bought three second-hand steamers, having failed to find builders able to quote for new tonnage. For the three boats, the company paid a higher rate per ton than they would have paid before the war for new vessels. Two years ago the little British schooner "Coquitlam City" was built on the Pitt River. She had her adventures and, becoming severely strained during a voyage, was laid up. The boat has just been chartered in San Francisco to load lumber for Australia next July. A $200,000 cement order recently had to be refused by a Canadian firm on account of the shortage in tonnage.

These are but three incidents of a tonnage shortage which is daily becoming worse. It affects the conduct and the length of the war and the transaction of business during the war. Its most serious effect is likely to come after the war, when we will all be clamoring for tonnage during the big commercial campaign which will then be waged.

In the House at Ottawa recently Sir George Foster, minister of trade and commerce, said that the government had made efforts to have vessels built. In the first place, it had asked responsible persons what amount of tonnage subsidy would be required to encourage the building of wooden vessels of economical tonnage, say, from 2,000 to 5,000 tons. In reply it had received an offer to construct such ships if a subsidy of $6 a ton were paid for 15 years, or $90 a ton in all. He did not think that was reasonable.

The government had also received an offer to build steel ships at the rate of from $125 to $135 a ton with delivery in the latter part of 1917. Sir George said the price was high and that the time of completion was too far distant. Therefore, he thought that it would be necessary to consider first the period of emergencies and then the period following the close of the war. As far as the latter period was concerned, he held that a country with Canada's producing capacity should have a considerable and a growing merchant marine, and that government assistance might be necessary to that end.

It is doubtful whether this country will be able to build many ships for "the period of emergencies," but it is certain that if we are to enter the shipbuilding business, with any success, for the period following the war, we must begin at once. Sir George Foster intimated that the government might be willing to co-operate in a shipbuilding enterprise.

Walter J. Francis and Co., consulting engineers, Montreal, have moved to more commodious offices in the new Bank of Toronto Building, 260 St. James St.

The Acting British Consul-General at Moscow reports on Railway Development in his district as follows in "Railway Gazette," London: Between Vladimir and Moscow on the Nijni line there is a large and important manufacturing district, of which Oriechovo-Zuevo is the chief centre. The factories in this district receive their cotton and much of their food supplies from the south, the goods in question coming by the Kazan line. Owing to the 10 versts (about 6½ miles) between Ilinski Pogost and Egorievsk, which would unite the Kazan and Nijni lines, not having been linked up by rail, the cotton for the Oriechovo-Zuevo manufacturing district has hitherto been compelled to travel up the Kazan line all the way to Moscow and then back by the Nijni line to Oriechovo-Zuevo. The connecting line between the Kazan and Nijni railways having recently been completed by linking up Ilinski Pogost and Egorievsk, and opened for traffic, it is estimated that the manufacturers of the latter town will be saved many thousand roubles yearly in freight charges. A similar project has been formed to connect the Yaroslav and Nijni lines.

MONTREAL AQUEDUCT PETITION.

Following is the text of the petition handed last week to the city council and board of control of the city of Montreal:—

"To His Worship the Mayor and the members of the Board of Commissioners of the city of Montreal.

"L. N. Senecal, Esq., Secretary.

"and to

"His Worship the Mayor and the members of the city council of the city of Montreal.

"Gentlemen,—

"Under dates of July 29, 1915, and October 7, 1915, the Council of the Canadian Society of Civil Engineers submitted to the mayor and council and to the commissioners of the city of Montreal then in office a recommendation that before further large expenditures were made on the enlargement of the aqueduct or toward the construction of the proposed hydro-electric power house at the pumping station the project should be studied and reported on by a commission of engineers of recognized standing in the profession.

"The Council of the Society communicated with all the engineers who had been named in the reply of Mr. Cote as having reported on the project, and learned that no one of them had studied and reported on it as a whole, but that only isolated portions of the work had been submitted to them for consideration.

"*The Canadian Engineer*, in its issue of November 11, 1915, published a comprehensive article in which it gave the history of the various enlargements of the aqueduct which have been considered, the estimated cost of the different proposals, and the approximate amounts which had been expended up to that time. It also gave the estimated probable expenditures still necessary to complete the enlargement of the aqueduct, the construction of intake and controlling works, the bridges and drains across the aqueduct and the building and equipping of the power house and pumping station. The data for the article were said to have been obtained from the engineers of the city, and the conclusions drawn as to the ultimate cost of the works appear reasonable. Unless the figures of cost given in the above-mentioned article are very far astray it would seem wise to re-consider the whole project and perhaps to modify it greatly.

"The opinion is quite generally held by local engineers having some knowledge of the work, but by no means full knowledge, that the proposed enlargement of the aqueduct and development of hydro-electric power sufficient to do the lighting of the city and to pump its water is not a project which could be recommended from an economic point of view.

"When the Council of the Canadian Society of Civil Engineers made its recommendation, many members were firmly of the opinion that:—

"(1) No thorough study had ever been made of the cost and economic value of the great enlargement of the aqueduct now proposed and of its attendant works.

"(2) No complete design had ever been prepared for the power house and its equipment or for the intake and controlling works, and only approximate estimates had been made of the cost of these very important and costly portions of the work.

"(3) The original estimates submitted by the engineers of the city were inadequate and the work as it progressed was costing far in excess of these original estimates.

"(4) The project as a whole had never been studied and reported on by independent or disinterested engineers.

"In view of all the circumstances, and particularly because of the fact that all the engineers named by Mr. Cote deny in writing the statement attributed to them that they approved of the project, we, the subscribing engineers, endorse and repeat the recommendation of the Council of the Canadian Society of Civil Engineers, and respectfully urge that a commission of prominent engineers, specially qualified to pass judgment on the project, be retained to make a comprehensive study and report upon the cost of the work as now projected, and to advise to what extent, if at all, the project may to advantage be modified or changed.

"Montreal, April 20th, 1916."

The petition was signed by the following Montreal engineers:—

Sir John Kennedy, consulting engineer; Ernest Marceau, superintendent-engineer, canals of the province of Quebec; Herbert Wallis, M.Inst.C.E., M.Inst.Mech. E.; K. W. Blackwell, vice-president, Canadian Steel Foundries; Phelps Johnson, president, St. Lawrence Bridge Co.; J. A. Jamieson, consulting engineer; Henry Holgate, consulting engineer; M. J. Butler, director, Armstrong, Whitworth of Canada; G. H. Duggan, general manager, Dominion Bridge Co.; R. A. Ross, consulting engineer; C. N. Monsarrat, chairman and chief engineer, Quebec Bridge Commission; Walter J. Francis, consulting engineer; Arthur Surveyer, consulting engineer; C. H. McLeod, consulting engineer and secretary of the Canadian Society of Civil Engineers; John B. Porter, consulting engineer and professor of Mining Engineering, McGill University; W. Chase Thomson, consulting engineer; H. M. MacKay, professor of Civil Engineering, McGill University; E. Brown, professor of applied mechanics and hydraulics, McGill University; H. O. Keay, professor of transportation, McGill University; G. R. Heckle, engineer and contractor; H. P. Borden, member Quebec Bridge Commission; James S. Costigan, consulting engineer; J. M. Robertson, consulting engineer; C. Lelau, professor at Laval University and consulting engineer; William McNab, valuation engineer, Grand Trunk Railway System; H. H. Vaughan, third vice-president, Dominion Bridge Co.; H. M. Jaquays, works manager, Steel Company of Canada; W. F. Angus, vice-president, Canadian Steel Foundries, Limited; R. J. Durley, consulting engineer; L. A. Herdt, professor of electrical engineering, McGill University, and member of the Montreal Electrical Service Commission; Alex. Pringle, consulting engineer.

Engineers employed by the various Montreal power companies were not allowed to sign the petition because Mayor Martin attributed the previous petitions to selfish interests on the part of the local power concerns, and the signers wished to make impossible such a charge in connection with the above petition.

The Scottish railway companies recently gave public notice that from March 20 the rate from Caledonian and North British stations to other stations in Scotland would, where they are not already at the maximum, be raised to the maximum, less 10 per cent.

GOOD ROADS ONE OF CANADA'S GREATEST NEEDS.*

By W. A. McLean, Deputy Minister of Highways, Ontario.

RURAL roads are the primary channel of traffic. Along them, production, industry and commerce have their origin. Let the common roads be closed, and railways will decay in idleness; ocean liners will rust at their moorings. Nations have prospered without railways; but common roads, "Good Roads," have always been vital to national progress and development.

The lessening of the cost of transportation is a measure of economy, of national thrift, which will produce a large return on the expenditure. On this continent, the cost of team haulage is rarely less than 25 cents per ton-mile and is sometimes twice that amount. Under the favorable conditions of good roads in Europe, the cost is reduced to between 8 and 12 cents a ton-mile.

The tonnage carried over the country roads of Canada is not readily estimated; but railway statistics show that the total amount of freight carried by the railways and originating in Canada, is about 60,000,000 tons. This, for the most part, at one or both ends of the railway journey, must pass over the wagon road. And a considerable additional amount, consumed locally, passes over the wagon road without railway transportation. The average wagon haul for farm and natural produce is estimated at between seven and eight miles. It is probably a moderate assumption for Canada that a total of not less than 100,000,000 tons passes over the roads of the country with an average haul of five miles.

Compared with European costs, good roads would effect a saving of not less than ten cents per ton-mile. Putting the amount saved at only five cents a ton-mile, or 25 cents per ton for the average haul of five miles, an adequate system of improved roads would create a profit of $25,000,000 annually on the produce and merchandise now passing over the roads of Canada.

The time lost in travelling over bad roads is very great. It has been estimated that bad roads occasion a loss of a man and team for two weeks (12 working days) annually to the average farm.

Bad roads limit the output of farms to the kind and quality of produce that can be drawn to market. Good roads permit the farmer to take advantage to the utmost of the location and fertility of his land. In other words, it may be broadly said that with bad roads the production is restricted to the produce that can be hauled over the roads; whereas with good roads it is restricted only to the amount and quality that can be grown and sold on the market.

If the nation and the city are to reap the advantage of increased farm population and production, rural conditions must be made to compete with city, by making them profitable and agreeable.

Road-building is clearly one of the most important public works remaining for Canada to undertake. When the war is ended and our armies return, with a large additional influx of immigration, it will be well if we are so organized that roads can be built on an adequate scale, not only to aid in the development of Canada, but, temporarily, to assist in giving employment during what will probably be a trying period of industrial readjustment.

Only a very wealthy country, improvident of its resources, can progress under the handicap of bad roads. Those who have bad roads consider good roads an expensive luxury. But those who have the advantages of good roads, know that Good Roads are a necessity.

Road-building is a slow process in part, because it is expensive. And because the work is expensive, it must be distributed over a term of years and among various administrative organizations. But so distributed, and looked at from the standpoint of annual ability, the undertaking becomes less difficult. The total twenty-year cost of maintaining a household does not worry the average man—if his annual income is sufficient for the annual outlay. Road-building is a continuous work; if properly carried on, is cumulative in its growth, and is a question of annual expenditure available to meet direct outlay, plus sinking fund, interest and cost of maintenance.

In the Dominion of Canada there are about 250,000 miles of graded roads. The immediate objective in Canada should be to substantially improve about 16 per cent. of the total, or 40,000 miles, which would carry the more concentrated market or farm traffic; while about 2 per cent. additional, or 5,000 miles, should be treated on a trunk road basis. The total cost might be approximately estimated at $250,000,000, of which about $50,000,000 has been spent.

*Reprinted from "Production and Thrift," Agricultural War Book, issued by the Department of Agriculture, Ottawa.

LETTER TO THE EDITOR.

Need of Sewage Disposal Plants.

Sir,—I have read with interest your editorial on the Lethbridge epidemic, but beg to differ from you regarding the solution of the problem.

The fact that the supply was being chlorinated raises the presumption that the authorities were aware that the water was subject to either continuous or intermittent pollution, and yet it is evident that the efficacy of the treatment was only checked by the examination of samples taken at long intervals.

Chlorination, when properly supervised, has been proved by scores of instances to be effective in preventing undue typhoid incidence, and the cost of such supervision is cheap compared with that of an epidemic.

If Lethbridge wishes to obtain a satisfactory supply, I would suggest that such means of purification be adopted as will ensure a water of safe quality, and not depend upon the prevention of pollution by some other authority. It is becoming deplorably prevalent for corporations to endeavor to place the responsibility for epidemics on other corporations because they have utilized the natural watercourses for the disposal of their sewage; and to petition legislative authorities for assistance when the remedy lies in their own hands. The sooner the cities of this Dominion realize that the rivers are the natural drainage courses for sewage, and that such streams must not be utilized for domestic purposes without proper purification, the quicker will typhoid become a disease of the past. Only when the sewage of one community so pollutes a river as to render it impossible for its neighbor to adequately purify it by reasonable measures, is there any warrant for interference. If one community neglects to protect itself, I cannot conceive that it is the duty of its neighbors to relieve it of that task. This is, of course, contrary to the principles of riparian law, but I submit that it is the sane solution of the problem if municipalities are not to be unduly burdened with excessive expenditures with consequent retardation of development.

JOSEPH RACE,
City Bacteriologist.

Ottawa, May 6th, 1916.

FOREST FIRES AND HYDRAULICS.

Robson Black, secretary of the Canadian Forestry Association, Ottawa, has distributed 25,000 copies of a booklet called "A Matter of Opinion," which is intended to educate the public to the importance of forest fire prevention.

Mr. Black discusses the matter from the viewpoints of the settler, the camper, the banker, the railway man, the power engineer, the fire ranger and the taxpayer. The discussion from the viewpoint of the power engineer contains the following interesting summary of the relations between forest fires and hydraulic engineering:—

A chain is no stronger than its weakest link, and a power development system is no stronger than the water supply that turns its turbines. But we cannot stop there. The best hydro proposition in America is just as reliable as the forces that control the water flow, and if those forces are out of hand, the entire undertaking, from the president in the head office down to the three horse-power consumer in the basement workshop, is likewise out of hand.

When I talk about controlling stream flow, I mostly mean forests. Some power propositions have to equalize the extremes of flood and drought by storage dams, but storage dams are to a certain extent "engineering crutches" to make up for a natural shortcoming. The million-dollar levees on the Mississippi are man's method of off-setting the effects of stripping the forests from the watersheds of countless streams back on the Ohio and other tributaries. The levees work—when they do work—and at an enormous annual expense, but had a reasonable amount of the original forest growth been left on the northern watersheds, the extent of levee building would have been considerably reduced and the menace of annual floods less to be feared.

I do not need to name the Canadian rivers from coast to coast—that run to flood during the spring break-up and to drought in midsummer. Every province has them. Whether in British Columbia or Nova Scotia, municipalities and factories and hydro-electric companies face the common difficulty of regulating stream flow so as to avoid dangerous extremes. Floods in Ontario, for instance, along such rivers as the Thames, Moira, Credit, and Grand, cause hundreds of thousands of dollars annual loss. Where shall we look for the cause?

Nature designed the forests on our watersheds to be the bit-and-rein of our streams. You have seen the thick spongy "floor" to a well-canopied woodland. That is nature's reservoir, designed for surplus waters of the spring break-up. Destroy this reservoir with fire or careless cutting, and the logic of nature loses no time in coming into play. Gravity has a clear field. And that spells flood, erosion of hillsides, damaged farmlands, streams out of hand, and hampered power facilities in the industrial towns.

Should there be, then, no cutting whatever on watershed forests? That would hardly seem reasonable. The rich agricultural lands will be stripped for field crops and their forest cover, whether valuable for watershed purposes or not, cannot be retained. The needs of agricultural expansion are supreme. Even on non-agricultural forested lands, it is only good economy to permit cutting under proper regulations regarding diameter limit. Taking out mature timber or pulpwood need not depreciate the value of a forest for watershed uses, although indiscriminate "skinning" will spell a speedy ruin. What I mean is that a spruce forest can be cut to a 12-inch diameter limit and yet 76.8 per cent. of the volume remain in growing condition. In other words, the reservoir properties would be unaffected. Protection against fire is, of course, most important of all considerations.

Natural forests perform a service for streams which cannot be measured in dollars. For power purposes we must often supplement with storage dams, for even in the primitive days before tree growth was touched by an axe, the inequalities of flow between spring and August were often too great to serve the needs of the modern power plant. At the same time, the living forest is a most necessary ally of the storage reservoir. Its functions are much the same and the absence of storage capacity in nature places that much more burden and expense on artificial devices.

I have not mentioned the danger to all storage and irrigation works, of the erosion of hillsides due to denuding of tree growth and the consequent silting up of the reservoirs. From that angle as from others forest destruction on watersheds plays the enemy to the power engineer.

ONTARIO HEALTH OFFICERS ASSOCIATION.

The Fifth Annual Meeting of the Ontario Health Officers Association will be held in Convocation Hall, University of Toronto, on Tuesday and Wednesday, May 30th and 31st, 1916. Programme for this conference is as follows:—

Tuesday, May 30th.

10.00-11.00 a.m.—Registration.

11.00 a.m.-12.45 p.m.—"The Quarantine Period for Measles," M. B. Whyte, Isolation Hospital, Toronto. "Measles," A. D. Smith, M.O.H., Mitchell. "Should the Breadwinner be Quarantined?" V. A. Hart, M.O.H., Vespra. "Some Observations on Typhoid Fever in Toronto," Fred. Adams, Epidemiologist, Department of Health, Toronto. "Epidemic Cerebro-Spinal Meningitis," J. G. Fitzgerald, Director Antitoxin Laboratories, University of Toronto. Appointment of committees: (1) Nominations; (2) Papers and Arrangements.

2.30-5.00 p,m.—President's Address, A. J. Macauley, M.O.H., Brockville. "Modern Methods of Diagnosis and Treatment of Diphtheria," W. H. Park, Director of Laboratory, Public Health Department, New York City. "Tonsils and Adenoids," G. R. Cruickshank, M.O.H., Windsor. "Suggestions for Improvement of Association Meetings," F. A. Dales, M.O.H., Stouffville. "Deductions of a New Ontario Medical Officer of Health," Edgar Brandon, M.O.H., North Bay.

8.15 p.m.—Public meeting. "Sanitation in Serbia," W. D. Sharpe, Major, R.A.M.C., Brampton (with views). War Scenes (views), Ruggles George, Capt., A.M.C., Toronto.

Wednesday, May 31st.

10.00 a.m.-12.45 p.m.—"Auxiliary Aids in Public Health Work," H. W. Hill, M.O.H., London. "Rural Sanitation," P. J. Moloney, District Officer of Health. "Methods of Collection and Disposal of Domestic Wastes in Small Municipalities," F. A. Dallyn, Provincial Sanitary Engineer. "Treatment of Sewage by Activated Sludge," T. Chalkley Hatton, Chief Engineer, Sewerage Commission, Milwaukee, U.S.A. Reports of Committees.

2.30-4.00 p.m.—"Prevention of Tuberculosis in Children," H. Logan, M.O.H., Niagara Falls. "Water Supply and Sewage Disposal for Suburban Residences," J. S. Nelson, M.O.H., Westboro. "Forms for Keeping Records of Communicable Diseases," E. C. Henderson, Assistant Statistician, Local Board of Health, London.

COAST TO COAST

Guelph, Ont.—The Board of Health has requested City Engineer McArthur to make a report on the city's water supply.

Sarnia, Ont.—The new Northern Navigation dock has been completed and is now ready for the use of the boats and wagons. The dock adds greatly to the appearance of the water front.

Quebec, P.Q.—The contractors on the St. Charles River improvements are busily engaged in dredging operations, so that navigation will be possible as soon as the locks and dam are finished.

Calgary, Alta.—A new proposition to provide pure water has been suggested by Ald. Fawkes. The scheme is one in which a series of filters would be installed, and would cost about $80,000.

London, Ont.—The London and Port Stanley Railway Commission has decided to purchase the incline railway at Port Stanley, running from the beach to Fraser Heights, from the Port Stanley Amusement Company for $1,600.

Montreal, Que.—M. J. Tremblay, chief of the fire department, has advised different commercial establishments that the city will shortly adopt the new system of underground wires for the special fire alarm system in the central part of the city.

Vancouver, B.C.—More than 22,000 feet, approximately 4½ miles, of the C.P.R. Roger's Pass tunnel under the Selkirk Range has been completed, and 25,000 feet, about 4¾ miles, of the main heading has been driven, according to late progress reports received by the C.P.R.

Ottawa, Ont.—Formal notice has been given by the government of a bill respecting the Quebec and Saguenay Railway. It is understood that under the terms of the measure to be submitted to parliament the sum of $4,000,000 will be set apart for the purchase and completion of the road.

Toronto, Ont.—The work on the Bloor Street viaduct is progressing very favorably. His Royal Highness the Duke of Connaught and Sir John Hendrie recently inspected the work and manifested great interest in the undertaking, which is perhaps the biggest the city has ever seen.

Moose Jaw, Sask.—The fifth annual report of the Moose Jaw Electric Railway Company, covering the year 1915, which has just been issued, shows the company to have operated at a gross profit of $6,402.19 during that year, though this profit was more than absorbed by some damage actions against the company.

Winnipeg, Man.—Construction operations have been resumed on the Shoal Lake aqueduct. With the exception of Boggy River, where water is holding up the engineers, every part of the aqueduct groove is dry. The construction companies will proceed on all their contracts and within a week the work will be general. With the experience gained last year it is expected that greater progress will be made during 1916 than in 1915. Possibly 1,000 men will be employed.

St. Catharines, Ont.—The work on the Welland Ship Canal as far as the contracts have been given out is progressing favorably, and all indications are that with the exception of the section at Thorold, where considerable blasting has to be done, the work will be completed on scheduled time. The work on sections 1, 2, 3 and 5, the sections for which contracts have been let, is progressing very favorably, and with the exception of section 3, will be finished on schedule time, 1917.

Owen Sound, Ont.—The dry dock proposition, which has been before Owen Sound off and on for the last six years, is again a live issue here. When in Toronto Mayor Little was interviewed by a Mr. Stephens, of Niagara Falls, who is desirous of promoting the dry dock scheme. The late Mr. Wood, who was behind it, and in whose hands it came almost to fulfilment, was from Niagara Falls, and Mr. Stephens expresses himself as willing to take up the plans where he left off. In 1912, the government agreed to grant the usual dry dock subsidy, and a by-law was passed in Owen Sound granting $200,000 toward the scheme.

Calgary, Alta.—The Rogers Pass tunnel is nearing completion, and according to recent reports it should be ready for traffic in a couple of months. To prevent water seepage the tunnel is to be completely lined with concrete. This work is now being carried on speedily, the cement for the work coming from the Canada Cement Company at Calgary. The Rogers Pass tunnel will be the first all-concrete-lined tunnel in Canada, and one of the few on this continent. It is an expensive procedure, but assures against ordinary slides and falling rocks within and the consequent danger of derailment and wrecks. This lesson was severely learned in the case of the spiral tunnels at Field, B.C., which were partly lined with timber and partly unlined in any way, and to this day have given great trouble from streams of seeping water in summer and ice in winter.

Toronto, Ont.—The failure of expert divers last fall to detect the defective cribwork in the new ship channel in connection with the reclamation work and harbor improvements at Ashbridge's Bay has necessitated the pressing into service of the hydraulic dredge "Tornado" of the Canadian Stewart Company. Owing to the muddy condition of the water it has been impossible for the divers to examine the work properly. In order to do the work more efficiently with the assistance of the hydraulic dredge sheet piling had to be installed across the channel, while it was found necessary to dyke the channel near the turning basin. Millions of gallons of water will have to be pumped out of the channel before the engineers will be able to make a proper inspection of the defective cribwork, a portion of which has already caved in and allowed the sand to pour into the bottom of the channel.

Hamilton, Ont.—The proposed coke ovens, which have been mentioned in this column before, are to be erected, according to representatives of the United Gas and Fuel Company, who were in conference with the Board of Control. Under the agreement the Hamilton By-Product Coke Ovens Company will commence at once the erection of its ovens here, the same to be completed and in operation in 1917. To take care of the intervening time, especially the coming winter months, the United Gas and Fuel Company has agreed to make such extensions to its artificial gas plant as may be required to maintain a supply equal to the demands. Furthermore, the company will conserve all the natural gas obtainable for use in this city. As to price, it was announced that the agreement was most satisfactory, the company having stated a maximum amount for both coke gas and also for the mixed product. In the latter case until the percentage of natural gas falls below half of the whole output, the price will remain at that charged for natural gas.

Editorial

MONTREAL ENGINEERS PETITION CITY TO INVESTIGATE AQUEDUCT ENLARGEMENT.

Thirty-one of the leading engineers resident in Montreal have handed a petition to the city council and board of control, again calling upon the authorities to appoint a commission of prominent engineers for a comprehensive study and report upon the aqueduct enlargement scheme. The text of the petition is printed upon another page of this issue.

There is no doubt but that the city council should at once grant the request and appoint a strong and entirely independent commission consisting of at least three qualified engineers, a banker who is conversant with the city's finances—Sir Frederick Williams-Taylor would be most acceptable—and, as chairman, some prominent Montreal business man who has the welfare of the city at heart, and who has been efficient and successful in general business matters, but who has never "mixed in" politically. This commission should be given funds and authority with which to work unhampered, and its hearings should be public. If necessary, it should be made a Royal Commission, appointed by Quebec. The matter is worthy of it. Some ten millions of dollars may be at stake.

Whether they ever recognize the fact or not, the citizens of Montreal owe a heavy debt of gratitude to the engineers of that city who have brought this matter to their attention, and who have kept at it, despite all discouragements. To J. A. Jamieson, R. S. Lea and G. R. Heckle must go the credit for having first brought the matter to the city's attention. These three men had been appointed by the city as consulting engineers to investigate the break in the conduit which happened in December, 1913. About March 1st, 1914, in reporting upon the conduit, they made five recommendations, of which the very first was,—

"That before any further work is proceeded with, at least on the north side of the aqueduct, an investigation be made by a commission of engineers into the entire aqueduct scheme, which will include revised estimates of the cost of construction and the quantity and cost of the power developed."

This recommendation was never adopted, and the three engineers got a hearty "call-down" for touching upon matters not directly bearing upon the conduit. However, from evidence that they had uncovered in their conduit investigations, they were convinced that such a commission was needed in the public interest, and Mr. Jamieson refused to let the matter drop. He wrote many public letters to Controller Cote concerning the situation, and it was not long before other public-spirited engineers, such as Sir John Kennedy, Walter J. Francis, Phelps Johnson, R. A. Ross, Arthur Surveyer, Richard Durley, Ernest Marceau and many others, took up the cudgels and secured action by the Council of the Canadian Society of Civil Engineers and by Montreal's Board of Trade.

It is plain, therefore, that the Montreal civic authorities have had this matter before them for more than two years. During those two years large sums have been spent on the work—sums which a commission may say have been spent uselessly. *The Canadian Engineer* endorses the request to the Montreal city council that this work be stopped until a commission has reported upon it. The scheme may be sound, but it should be proven so, clearly and above-board. It is more imperative now, than ever before in the Empire's history, to prevent all economic waste. Remember the silver bullet!

WATER TRANSPORTATION IN CANADA.

In the March 2nd issue of *The Canadian Engineer* there appeared a paper on "Economic and Strategical Aspects of the Enlargement of the Welland Canal and of Construction of the Georgian Bay Ship Canal."

This paper was presented before the Canadian Society of Civil Engineers by Major R. W. Leonard, Mem.Can. Soc.C.E.

The following issue of the paper contained a discussion of this interesting theme, in which different aspects of the project were dealt with.

The question of transportation in Canada is receiving particular attention at the present time, this attention, undoubtedly, being accentuated by the fact that the war is expected to introduce new problems which will be intimately related to transportation in more ways than one.

A great deal of discussion has been given to the Georgian Bay Canal. Pamphlets approving and disapproving of the project have been printed and circulated by the thousands—special articles have appeared in all kinds of publications, and it is doubtful if any single engineering project has brought about so much discussion as it has.

In view of the importance of the transportation problem in Canada, it is to be hoped that the duties and hours of the Georgian Bay Canal Commission will be extended so as to include a thorough investigation of the whole subject of water transportation between the Lower St. Lawrence and Lake Superior by the St. Lawrence and lower lake route, as well as by the Ottawa and Georgian Bay route, and that the advantages and disadvantages of both routes be exhaustively compared with each other and also with lake and rail transportation via Georgian Bay, and by all rail routes via railways already built or hereafter to be built, because it is only by considering the Ottawa and Georgian Bay route as one of two great water routes and again by comparing these with the upper lake and rail route and with all rail routes that the Georgian Bay Canal project can be properly and intelligently dealt with.

If the Commission were empowered to extend its investigations along these lines, it would necessarily include some new surveys and estimates for dealing with the St. Lawrence and its canals and water power sites between Montreal and Prescott. Such surveys could be quickly made and at a cost which would be insignificant as compared with their value in enabling the Commission to arrive at conclusions which would be more satisfactory in every way.

PERSONAL.

P. TURNER BONE was re-elected president of the Alberta Sewer Pipe Company, of Calgary, at the annual meeting.

P. G. MAHONEY, M.L.A., has been appointed to succeed the Hon. John Morrissy as Minister of Public Works for the Province of New Brunswick.

L. G. IRELAND, general manager of Brantford Hydro-Electric Commission and Brantford Municipal Railways Commission, has handed in his resignation, to take effect at the end of May. He has been appointed chief engineer of new Hydro development in Eastern Ontario.

GEORGE McKNIGHT has been appointed city engineer of Fredericton, N.B. Mr. McKnight was formerly with the Transcontinental Railway on construction, and latterly with the St. John and Quebec Railway.

Capt. E. T. STERNE, of the Engineers, Kingston, has been loaned by the Militia Department to the Imperial Munitions Board to act as inspecting chemist of Tri Nitro Toluol at the Montreal plant Canadian Explosives, Limited.

L. G. McNEICE, B.Sc., who for three years was in London in the interests of Engineers Chipman and Power, has been appointed general manager of the public utilities at Wallaceburg. Mr. McNeice recently installed the new waterworks and sewage farms at Wallaceburg. In his new position he will have full charge of these and also of the electric department.

THOS. L. HINCKLEY, B.S., has been appointed engineer to the Bureau of Municipal Research, Toronto. Mr. Hinckley is a graduate of the Massachusetts Institute of Technology, from which he graduated in 1906. Since then he has been engaged in sanitary engineering, having been connected with the design and construction of water supply and sewage disposal works at Columbus, Ohio, Montreal, Que., and other places. For the past four years Mr. Hinckley has been especially interested in municipal research work in various cities.

LIST OF OFFICERS OF No. 1 CONSTRUCTION BATTALION.

Among the officers of No. 1 Construction Battalion, stationed in Toronto, are the following, who have been appointed under Lieut.-Col. B. Ripley:—

Captain and Adjutant T. R. Loudon, civil engineer, who is well known in Toronto, having been assistant professor of ferro-metallurgy at Toronto University and of late a member of the firm James, Loudon & Hertzberg, consulting engineers. He has for some time been instructing at the militia headquarters at Toronto.

Captain J. H. Byrne, civil engineer, graduate of the Royal Military College. He has been connected with the National Transcontinental Railway as district and government inspecting engineer and has had long and varied experience on construction, chiefly of railways.

Captain R. R. Holland, civil engineer. He has been actively connected with the construction of railways and other important engineering works for the past fifteen years, having filled positions as resident engineer, assistant engineer and division engineer on both the C.N.R. and National Transcontinental Railways.

Captain A. R. Ketterson, civil engineer, at present assistant bridge engineer of the Canadian Pacific Railway at Montreal. He has also represented the bridge engineer on Western lines C.P.R., and has had long and varied experience in engineering and construction both in Canada and Scotland.

Captain Quartermaster Victor G. Davis, formerly of the purchasing departments of both the Canadian Pacific and Canadian Northern Railways. Has also qualified as a lieutenant.

Lieutenant G. O. Fleming, civil engineer, graduate S.P.S., Toronto; experience being chiefly on construction connected with the Toronto Railway Company and with the engineers at militia headquarters at Toronto.

Lieutenant J. B. Heron, civil engineer, well known in Toronto, who has had a long experience chiefly at railway construction. This officer has had South Africa experience, having fought in the Boer War.

Lieutenant Fred. G. Cross, civil engineer, for nine years with the Canadian Pacific Railway in Western Canada.

Lieutenant H. R. McQueen, civil engineer, graduate of the Royal Military College; experience in both mining and railway work.

Lieutenant O. P. Hertzberg, civil engineer, for some years connected with the engineering department of the C.P.R. For two years he was with Lieut.-Col. Ripley on grade separation in Toronto. This young man was in several engagements in the present war and is now recuperating at home.

Lieutenant H. L. Gilmour, civil engineer, well known in Ottawa; graduate of McGill University; has been prominently connected with the lumber industry in the Ottawa valley.

Lieutenant Geo. S. Grant, contractor and construction man, well known in Ottawa, and a son of the late Mr. Hugh Grant, well-known contractor, having been connected prominently with the building of the Intercolonial Railway in Cape Breton.

CANADIAN SOCIETY OF CIVIL ENGINEERS—ELECTIONS AND TRANSFERS.

At a meeting of the Council of the Canadian Society of Civil Engineers held April 18th the following elections took place:—

Member—Thomas Taylor, Toronto.

Associate Members—Louis Napoleon Boulet, Montmagny, Que.; Andrew Galloway, Victoria, B.C.; Albert Walker Haddow, Edmonton, Alta.; J. M. Maurice LaForest, Montreal; Charles Ross Lindsey, Shawinigan Falls, Que.; Edlin Geo. Wm. Montgomery, Regina, Sask.; Kenneth Stockton Pickard, Sackville, N.B.

Juniors—Horace Malcolm Bigwood, Victoria, B.C.; George Fleming Irving, Winnipeg, Man.

The Council also announce the following transfers:—

From Associate Member to Member—Allan Beacon Aitken, Quetta, Baluchistan; G. Gordon Gale, Hull, Que.; Chauncey Marsh Goodrich, Detroit, Mich.; John Bell McRae, Ottawa.

From Junior to Associate Member—Halfden F. H. Hertzberg, Toronto; Norman Marr, Campbellford, Ont.; Robert Bruce Stewart, New Glasgow, N.S.; Jas. LeRoy Whitside, Winnipeg, Man.

From Student to Associate Member—Leonard Joseph Bisson, Fort William, Ont.; Donat Paquet, Montmagny, Quebec.

From Student to Junior—William Layton Frame, Vancouver, B.C.; Alfred John Lawrence, Montreal

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

ACTIVATED SLUDGE EXPERIMENTS AT MILWAUKEE.

SOME FURTHER INTERESTING FACTS CONCERNING THE PROCESS BROUGHT OUT BY THE EXPERIMENTAL WORK CARRIED OUT AT MILWAUKEE.

By R. O. WYNNE-ROBERTS, M.Can.Soc.C.E.

IN a previous article on this subject in the issue of April 27th attention was paid to the general results obtained at Milwaukee. There were, however, many additional interesting investigations made into different features of the process. These included the efficient diffusion of air, period of aeration, and volume of air required, effects of temperature, production and dehydration of sludge, inoculation of sewage with activated sludge, and so on, all of which are valuable studies and tend to render the process more efficient and economical. Most of these are confirmatory or enlargements of experiments made by Messrs. Ardern and Lockett in 1914.

Diffusion of the air in the sewage has been experimented upon by means of filtros plates, monel metal, and air jets. Filtros plates are made of quartz sand cemented together and baked, and are supposed to be made of any porosity desired. But, out of 530 plates, each 1 ft. square, only 60 per cent. complied with the specification that 2 cu. ft. of air per minute be passed through each dry plate 1½ ins. in thickness, under a pressure of 2 ins. of water, with a marginal allowance of 5 per cent. either way. When the plates are wet the pressure increases 10 to 12 times. For example, with 8 ft. of liquor the filtros plates required 4.6 lbs., that is, 1.12 lbs or 31 ins. in excess of the static head, or 15 times the pressure required when the plates are dry. Mr. Chalkley Hatton states that the bubbles were too large to produce the greatest efficiency. He expresses the opinion that the excess pressure might be reduced by making the plates thinner and reinforcing them like wired glass. He found that when the air bubbles were 1/16 in. or less in diameter they were in contact with the liquor in a 10-ft. deep tank from one to four minutes, but when the diameter of the bubbles exceeded the above dimension the contact was only but a few seconds. The economy in the use of air is to be attained by prolonging the contact until the oxygen has been absorbed, but the problem is to secure such prolonged contact. "Several mechanical devices have been designed and operated to break the air globes into smaller globes, but so far they have not been satisfactory."

Mr. Copeland states that filtros plates are very irregular in porosity. Some would pass 10 ft. and others less than 0.5 ft. of air, whereas 2 cu. ft. was stipulated. Dense plates gradually choke with sludge, and a mixture of dense and porous plates in a tank results in unequal aeration. "Bacterial growth on plates might require sterilization for their removal."

Fine-woven monel metal cloth has been tried and smaller bubbles issue from the surface of the cloth than from the filtros plates, although the former is more porous than the latter. There is also less frictional loss than through plates.

Open air jets reduce the pressure required but also reduce the efficiency because the bubbles are too large. An orifice 1/1000 of an inch in diameter under 5 lbs. pressure discharges air bubbles 1/32 inch in diameter. Dust, however, will tend to choke such a small orifice. Sludge enters into open jets and cakes within. This was the difficulty experienced at Salford, England, where open jets are largely used. Mr. Copeland suggests flushing such pipe with water under pressure.

Comparison Between Filtros, Air Jet and Monel Metal Diffusers.

Diffusers.	Period. 1915.	Pressure lbs.	Cub. ft. air per gallon.	% Bacteria removed.	Nitrate formed. p.p.m.	Stability of effluent. hours.
Filtros	June 1	4.3	2.5	91	3.4	78
Air jet	Aug. 12	3.5	2.3	91	2.2	52
Filtros	Nov. 18	4.6	2.1	90	0.3	113
Monel Metal	Dec. 7	3.0	2.1	80	0.2	63

Mr. Copeland states that "open air jets have given good service—almost as good, in fact, as the filtros plate, but they have one bad feature," namely, the sludging up of the orifice. This would indicate that a device similar to one used by the writer might obviate the trouble; that is, to hinge the pipes, and before the air is shut off, swing the pipes out of the tank. Where there are a number of such pipes it requires some ingenuity to arrange the air pipes to avoid complications.

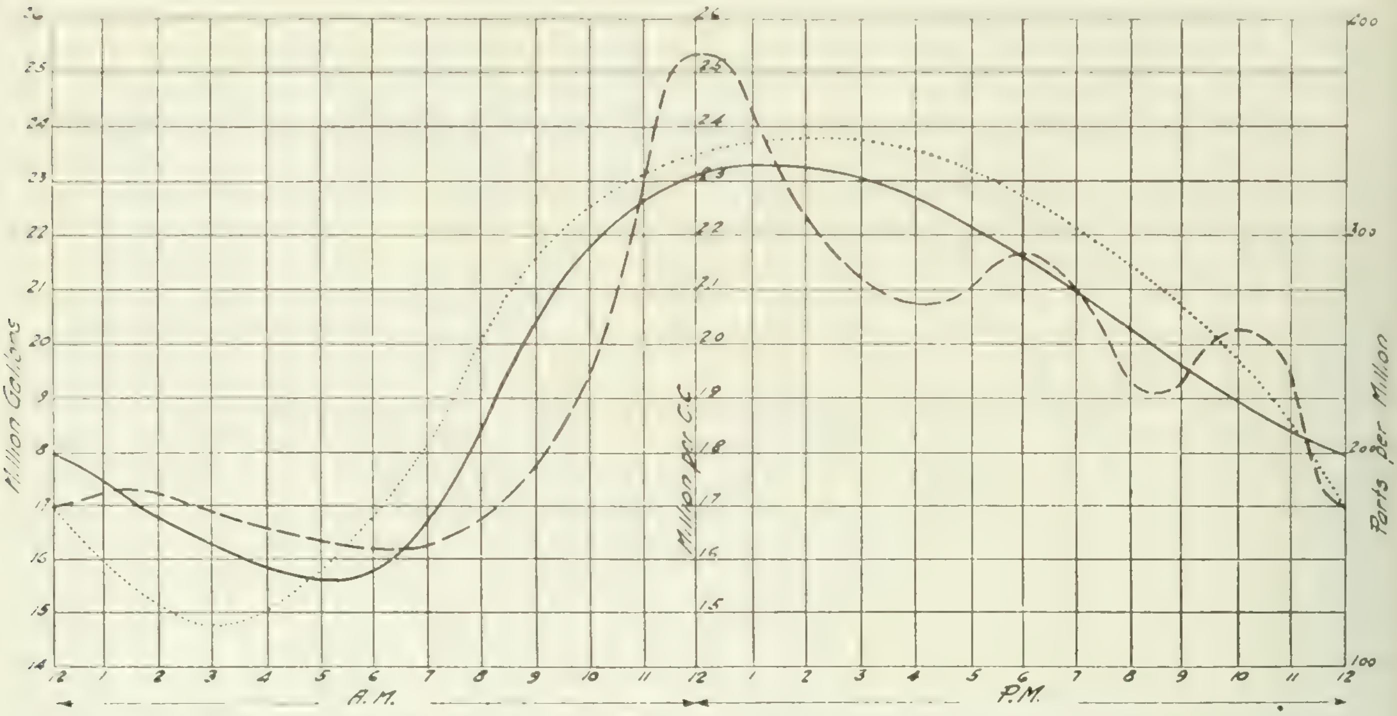
Mr. Copeland mentions a pertinent statement with regard to increasing the depth of tanks so as to prolong the air contact. This matter has also been referred to by Messrs. Ardern and Lockett. The quantity of air per square foot of tank area or per acre will, in a given time, purify more sewage or purify a given quantity to a greater extent in deep tanks than in shallow ones. But deep tanks will require greater pressure and the supply of air will cost more. Whether the advantage will remain with the deep water tanks is not yet proven.

"Our supplementary experiments," according to Messrs. Chalkley Hatton and Copeland, "indicate that more efficiency of air can be obtained in deeper tanks (than 8 to 10 ft.) by reason of the longer contact period between air and sewage, and the tendency of the air, as it escapes from the diffuser, to break into smaller bubbles, because the pressure head is increased. Local conditions might, and probably would, largely control the depth of tank."

The period of aeration and volume of air required under different conditions are matters of importance. As all sanitary engineers know, the flow and strength of

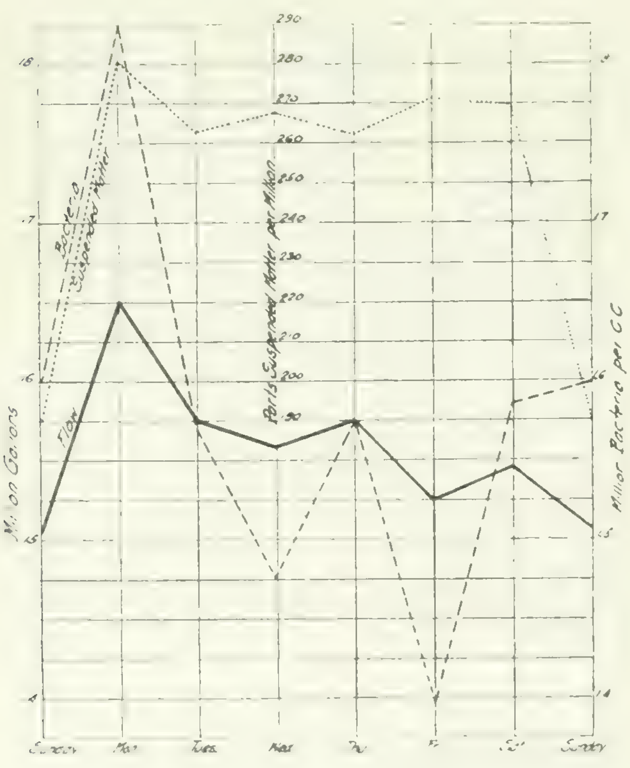
sewage changes throughout the day. The following diagram, taken from the report, will illustrate the average hourly fluctuations of sewage flow at one of the outlets of Milwaukee, as well as varying proportions of suspended matter and bacteria.

According to the diagram, the flow of sewage was lowest at about 5.0 a.m., when it was 80 per cent. of the daily mean, and the greatest flow was at 1.0 p.m., when it was 118 per cent. of the daily mean. The flow from midnight to 8.0 a.m. was 30 per cent. of the mean, so



Showing average hourly discharge of sewage over 20-foot weir from the Menomonee intercepting sewer during 1915. Average flow represented by solid line. Average suspended matter represented by dotted line. Average bacteria per c.c. represented by dashed line.

The next diagram shows the average daily characteristics of the sewage during the year.



Showing certain characteristics of sewage flow from the Menomonee intercepting sewer for the year 1915.

that 30 per cent. was discharged in 9 hours and 70 per cent. in 15 hours.

The following table affords excellent examples of the fluctuating flow and composition of sewage during different periods of the day:—

Volume of Flow and Composition of Sewage During Different Periods of the Day.

Date 1915 Period	No. of Gallons of Sewage	Settleable Solids Cu. Yards per Mil Gals.	Parts Per Million: Suspended Matter	Oxygen Consumed	Organic Nitrogen	Free Ammonia
April 1st—						
24 hours ...	12,300,000	17.5	226	159	37	18.2
12-7 a.m. ...	3,217,000	2.0	70	89	26	14.6
8 a.m.-3 p.m.	5,343,000	32.0	280	193	58	21.2
4-11 p.m. ...	3,740,000	18.0	240	183	38	15.2
April 29th—						
24 hours ...	13,070,000	19.0	293	174	52	17.2
12-7 a.m. ...	3,430,000	4.5	117	70	21	14.7
8 a.m.-3 p.m.	4,960,000	22.0	791	264	92	25.2
4-11 p.m. ...	4,680,000	13.0	254	156	40	15.2

From the data given in this table it is plain that the disposal plant will have to handle a volume between the hours of 8 a.m. and 4 p.m. that is 30 to 40 per cent. greater than between the hours of midnight and 8 a.m.; and that liquor will in addition be from twice to three times as strong. In short, the plant will have to provide an increase of 100 per cent. in the capacity for purification to meet the overload from 9 a.m. to 4 p.m.

Whereas the volume of sewage will increase, the tank capacity will remain the same; therefore the rate of flow

through the plant will increase. If the rate of aeration is kept constant the increasing sewage flow will meet a decreasing proportion of air. Such procedure might overload the activated sludge with organic matter. In our new plant arrangements have been made to store such sludge in tanks with continuous aeration during the period of weak night flow for the purpose of oxidizing the undigested materials. This purified sludge will then be in extra good condition to attack the strong sewage of mid-day.

Mr. Copeland compares the results obtained on Sundays and Mondays and the table below gives the average of four such comparisons.

Relative Purification of Weak and Strong Sewage by Activated Sludge (Fill and Draw.)

Analysis of Treated Sewage.

Day of Collection	Average Number of: Gallons Treated	Cu. Ft. of Air Per Gal.	Mil. of Bacteria per c. c. 20° c.	Parts Per Million: Suspended Matter	Oxygen Consumed	Nitrogen as: Organic Nitrogen	Free Ammonia	Data Regarding Effluent: Stability in Hours	Nitrates P.P.M.
Sunday . . .	74,190	2.03	3.11	136	68	27	14.9	. .	. .
% Removed	. .	. .	96	99	71	65	60	. .	. .
Monday	74,100	2.26	3.37	343	111	28	13.9	120	5.9
„ Removed	. .	. .	96	96	83	75	64	. .	. .

"Estimating the comparative strengths of these sewages by the amount of suspended matter contained, we see that the Monday sewage was about twice as strong as the Sunday sewage. By increasing the air from 2.03 to 2.26 cu. ft. per U.S. gallon, or 10 per cent., the stronger sewage was treated satisfactorily." On one Monday the suspended matter was six times as much as on the preceding Sunday, and yet 1.8 cu. ft. of air per gallon took care of this strong sewage as 1.9 cu. ft. per gallon took care of the Sunday liquor. Liquor containing as much as 600 parts of suspended matter per million have been successfully treated with less than 2 cu. ft. of air per U.S. gallon. Assuming the quantity of air at 2 cu. ft. per U.S. gallon, which is equal to 2.4 cu. ft. per Imperial gallon, and basing a calculation on four hours' aeration,

then, $\dfrac{22{,}200 \text{ gallons} \times 2 \text{ cu. ft.}}{4 \text{ hours} \times 330 \text{ sq. ft.}} = 33$ cu. ft. per square

foot of tank area per hour, which seems high compared with the results obtained by Messrs. Ardern and Lockett and Dr. Edward Bartow.

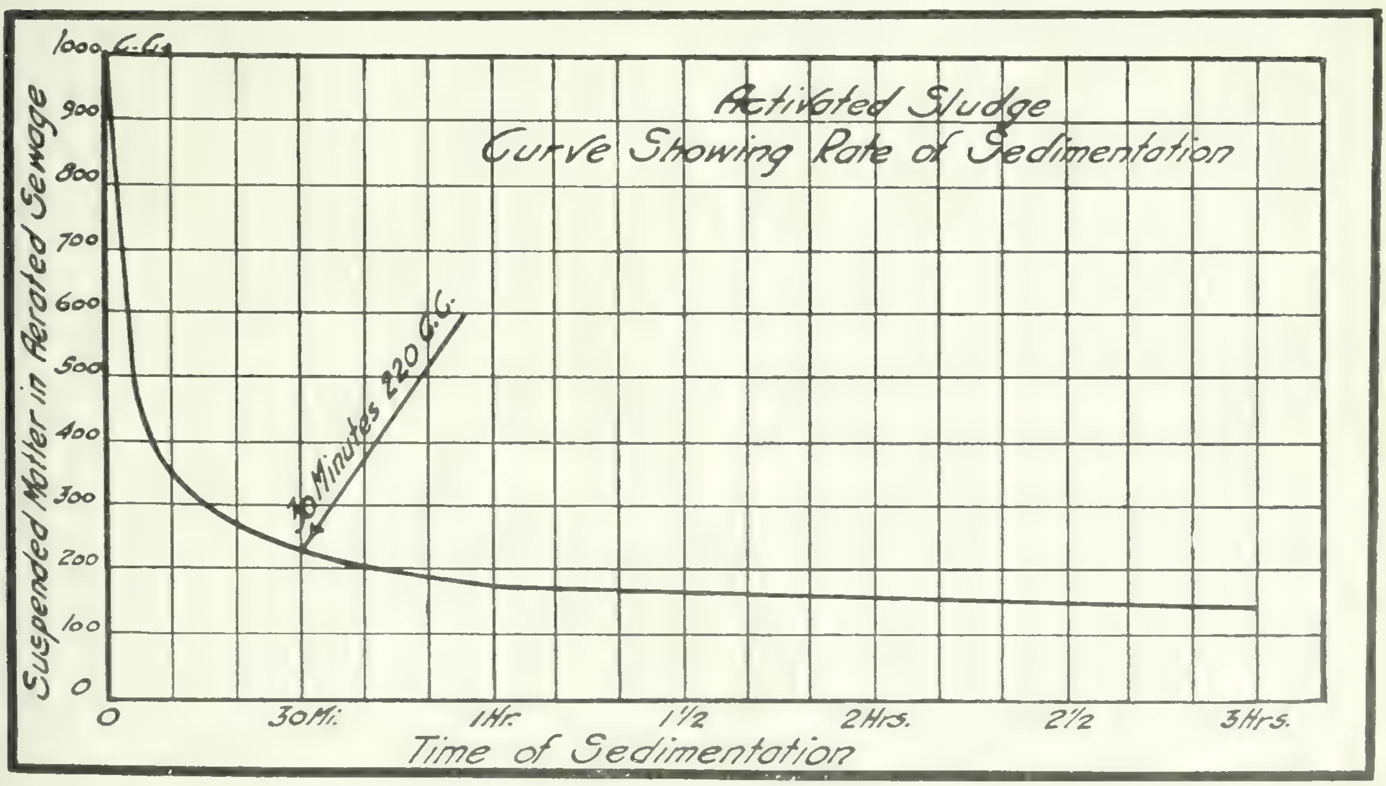
Mr. Copeland supplies a table showing the progressive steps of aeration.

Purification of Sewage Obtained Compared with Period of Aeration.

Period of aeration, in hours	0	1	2	3	4	5
No. of cu. ft. of air per min. . .	0	100	100	100	100	100
Cu. ft. of air per gallon	0	0.66	1.33	1.99	2.66	3.22
*Appearance of settled liquor.	Turbid.	Clear.	Clear.	Clear.	Clear.	Clear.
Stability in hrs. .	0	2	33	120+	120+	120+
% bacteria removed	0	52	81	92+	95+	98
Parts per million:						
Free ammonia.	22	17	15	11	7	5
Nitrite	0.08	0.00	0.95	1.75	2.20	2.50
Nitrate	0.08	0.04	0.70	2.80	5.00	8.20
Dissolved oxygen	0.00	0.30	1.00	4.30	5.90	6.70
Cost per million gallons		$1.40	$2.82	$4.25	$5.64	$8.10

*NOTE:—The suspended matter carried by the sewage on this date ran 235 parts per million and the supernatant liquor after 1 hour aeration contained not more than 10 parts per million.

These data point clearly to the fact that well activated sludge coagulated the colloidal matter about as completely



Showing rate of settlement of activated sludge in quiescent liquor. Average curve.

[illegible] as it did in five; by three hours it had removed over [illegible] per cent. of the bacteria from the supernatant liquor and made it stable for a period of more than 5 days.

The sludge was in good condition when this test was made, and the air was applied in such a large volume that by the end of the 5-hour run 3.2 cu. ft. had been added per gallon of sewage treated.

One of the interesting things to note about this table is that so far as clarification was concerned, we got as good efficiency for \$1.40 as we did for \$8.10; and as good stability for \$4.25 as for \$8.10. While the bacterial removal obtained for \$4.25 was quite sufficient for any ordinary sewage disposal plant.

As purification of sewage by aeration bears a close relation to the volume of air applied, it is instructive to study the following table:—

Relation Between Volume of Air Applied and Purification Obtained by the Continuous Flow Process.

Average Number of				Parts Per Million—Nitrogen as—			
Cubic Feet of Air Applied Per Gallon	Gallons Treated Per Day	Stability in Hours	of Bacteria Removed	Free Ammonia	Nitrate	Organic Nitrogen	Suspended Matter
1.81	62,000	120	98	1.95	8.5	4	11
1.53	65,000	120	99	5.79	9.0	8	9
1.12	65,000	73	91	10.10	2.3	14	42

During the periods covered by the preceding table the liquor required about 5 hours to pass through the tank. The data show that air applied for five hours at a rate of 1.53 cu. ft. per gallon purified the sewage well, but when applied at a rate of only 1.1 ft. the stability obtained was not satisfactory.

The raw sewage often contained H_2S and other foul elements, but by introducing this liquor a few feet below the surface of tank No. 2 these smells were all absorbed.

In fact, the continuous flow process may be described as being odorless, free from the flies which infest sprinkling filters, and capable of destroying the dyestuffs carried by sewage. Fats and other floating materials collected on the surface of the settling basin back of the weir. These were removed occasionally to prevent them from making a thick cake. During very cold weather ice formed around the edges of the tank, but the agitation caused by air and the warm temperature of the sewage kept most of the surface open.

The effects of temperature must be considered, because when the sewage falls below about 60° F. it was found by chemists that the activity of the process was reduced. The lowest sewage temperature recorded at Milwaukee during 1915 was 49° F. The minimum sewage temperature during 1914-15 winter was 44° F. Nitrates were formed during May, 1915, at sewage temperatures ranging from 49° to 54° F. and several parts were formed, even in two hours when plenty of air was applied. Large excess quantity of air was supplied to get the sludge well activated.

Mr. Chalkley Hatton, in February last, was good enough to furnish the writer with information concerning the temperature of the atmosphere, sewage, and effluent at Milwaukee on certain dates which are now tabulated as follows:—

Date (1916).	Temperature of — Atmosphere.	Sewage.	Effluent.
Jan. 13 to 18	From 10° to +4° (Average −3°)	Aver. 46°	Aver. 48°
Jan. 21 to 23	Average +32°	Aver. 43°	Aver. 44°

He found that during the cold weather the temperatures had an appreciable influence upon the process; although nitrates were absent, bacteria were reduced 90 to 98 per cent.; suspended matters, 96 to 98 per cent., and the stability ranged from 44 to 120 hours, averaging 118 hours. The two-million-gallon plant, however, was started only a short while before the cold weather set in and it is possible that in an established process the effect of low temperature on the formation of nitrates would be less pronounced.

The temperature of sewage in certain cities is practically always below 60° F. In one place the average ranged from 38° F. in January to 60° F. in August, and after passing through the settling tanks there was an average loss of about one degree and in the percolating filters another 2 to 3 degrees.

Messrs. Ardern and Lockett stated in May, 1914, that with temperatures constantly below 50° F. nitrification was practically inhibited within a period of nine hours' aeration and that the effect would be cumulative over a prolonged period of working, with the probable eventual production of inactive sludge.

At first the writer anticipated difficulties would occur in winter seasons, but the problem is not so serious when the relative specific heats of air and sewage are considered. This matter is full of interest to those concerned in the treatment of sewage by this process.

The production of sludge is of course necessary, and it "must be activated; that is, it must be alive with the aerobic nitrifying bacteria which play the most important part in the process. In other words, the nitrogen cycle must be established and this cycle must be maintained." By the nitrogen cycle is meant the conversion of the ammonia into nitrite and then into nitrate.

Activated sludge may be built up from several sources. Where the sludge retained in a final sedimentation tank from percolating filters, is available it is one of the best seeds for starting activated sludge, because it is already activated with aerobic bacteria from the filters. An anaerobic sludge from Imhoff tanks can be turned into an aerobic activated sludge by using sufficient air during long periods; or the sludge present in the raw sewage can be built up to activated sludge by using sufficient air and sewage on the fill and draw principle.

The efficient activation of sludge was indicated "by the fact that the settled liquor was clear, free ammonia had practically disappeared and the sludge contained more than two parts per million of nitrates."

The quantity of sludge retained in a tank ranging from 30 to 18 per cent. did not affect the degree of purification to any marked degree, but in another part of the report Mr. Copeland states: Our data show that a volume of sludge equal to 20 per cent. of the cubical contents of the tank gives good purification. In the presence of 25 per cent. of sludge more nitrates were formed but the increase in efficiency was not so great as to point clearly to the necessity of having the larger volume. Moreover, as the volume of sludge decreases the room for sewage in the tank will increase, as well as the number of gallons treated per acre."

As this review has already exceeded the limits intended the writer will not discuss this point further.

The diagram on the preceding page indicates the average rate at which activated sludge settles in still water.

Dehydration of Sludge.—It is estimated that at Milwaukee about 15 cu. yds. of sludge per million gallons will be obtained. Activated sludge is very flocculent and contains 98 per cent. of water. When dried to 10 per cent.

moisture the weight will then be about one-half ton per million U.S. gallons. Dehydration by pressing, centrifuging, heating, gravity, etc., have been either tried or considered. Early in our activated sludge process we realized that there was sufficient value in the sludge in the form of unsaponifiable grease and ammonia nitrogen to warrant its being dehydrated, degreased and dried for fertilizer base. Several samples were sent to fertilizer producers in Chicago who reduced them and reported their worth to be from $10 to $20 per dry ton, with plenty of market for all we could produce.

The sludge produced by the process has the general appearance of finely divided sponge, brown in color, and seems to absorb the colloidal matter very rapidly. Highly colored liquor introduced into activated sludge will be decolored in a few minutes.

It drains out upon the ordinary sludge-drying beds in less than one-half the time of the Imhoff tank sludge, but this dewatering is accomplished differently; the first liquor removed from the sludge passes downward through the bed, upon the surface of which the sludge settles, whereupon the remaining liquor rises on the top of the sludge and must be drawn off. The sludge has no apparent odor.

Its moisture content can be reduced from 98 per cent. to 94 per cent. by pressure due to a 26-foot head of water and its volume decreased 40 per cent.

An interesting feature of the process is the inoculation of the sewage by activated sludge. Mr. Copeland states that "in order to purify sewage to best advantage, activated sludge must be fed to the raw sewage as it enters the tank," and to do this he considers that the sludge should be concentrated by hydrostatic pressure. It is known that sludge from a two-story tank contains less water as the depth at which it is digested increases. Four hours' storage in a 3-in. pipe 26 ft. high at Milwaukee resulted in the moisture being reduced from 98 to 94 per cent., so that 100 units were reduced to $100 \times \frac{100-98}{100-94} = \frac{2}{6} = 33.33$. The sludge was raised by an air-lift pump. No information is given as to the proportion returned to the sewage inlet. The report, however, states that "there is no necessity of returning more than enough sludge to keep the tank charged with its proper proportion, but in order to secure the proper proportion it was necessary with the apparatus at hand, to return a large excess of treated liquor with the sludge." To return more than this volume forces liquor through the tank at an unnecessarily high rate, with the result that the sewage will get insufficient treatment. On the other hand, if the sludge is not pumped out of the settling basins fast enough it will fill them up and run out of the overflow. In order to avoid these difficulties the discharge from the sludge lift should be run into sludge treatment tanks. Most of the sludge will flow as freely as water, and on the same slope, but the heavier masses of sludge consisting of waste, paper, etc., do not flow readily and therefore the sides of the pipes or troughs must be smooth.

The term "proper proportion" may perhaps be interpreted as the percentage of the tank capacity occupied by sludge, say, 25 per cent. settleable in 30 minutes. Attention has already been drawn to the plan of storing and aerating sludge during the hours of weak night flow, so that it will be in good condition to attack the strong sewage of mid-day.

Despite the fact that there is yet much to learn—and what process is there which has reached its perfect stage of finality?—the activated sludge system of sewage treatment has been established as one which will produce better results than any other known method, excepting possibly land irrigation under exceptional conditions.

Municipal engineers owe much to Messrs. Chalkley Hatton and Copeland for conducting experiments on a large scale to prove the practicability of the process evolved by Messrs. Ardern and Lockett under different conditions.

The writer acknowledges his indebtedness to the above gentlemen and to Mr. John H. Fowler for information bearing upon the important subject under review.

LETTER TO THE EDITOR.

Revision of the Patent Act.

Sir,—Your issue of May 11th contains a letter with suggestions as to the amendment of the Patent Act and improvements in patent practice, made by Mr. W. S. Babcock, of Montreal. With some, at least, of these suggestions we are heartily in accord. The patent and the trade mark branches of the Patent Office will never get sufficient attention as long as they are merely adjuncts of the Department of Agriculture, the head of which is usually someone whose interests and experience are largely agricultural.

The suggestion that patentees be given the option of having their patents subjected to compulsory manufacture or compulsory license, is a good one. The manufacturing section of the act in the past has been more of a nuisance to patentees than of benefit to manufacturers. It may also be advisable to have interferences decided by an official of the patent office, as the proper weighing of the various points which require to be considered in an interference case necessitates special experience, not only in the consideration of evidence, but in the consideration of the various points of the invention in issue. The average arbitrator appointed by the government often falls woefully short in the latter feature. We have not noticed, however, that the interference proceedings in the United States office are very much cheaper than the decision of a Canadian interference by arbitration.

As to the substitution of a continuous term of eighteen years, with a somewhat increased first payment, in place of the present renewal system, there may be differences of opinion. It is often of considerable advantage to get rid of the patents which are allowed to expire at the end of the first six years of their life. It greatly reduces the number of patents that have to be kept in mind when determining the question of infringement. It is quite possible that the provision of extensions of time for payment of renewal fees on the payment of certain fines would meet the requirements.

Our suggestion would be that the government appoint a commission including representatives of the patent office, patent attorneys, lawyers, inventors, and manufacturers, to consider the whole situation and to make recommendations for revision of the Act, improvement in the organization of the patent office, and improvements in patent procedure.

RIDOUT & MAYBEE,

Solicitors of Patents, Toronto.

Per J. Edward Maybee.

Toronto, May 15th, 1916.

RULES FOR CONDUCTING PERFORMANCE TESTS OF POWER PLANT APPARATUS.

IN 1909 a Power-test Committee was appointed by the American Society of Mechanical Engineers to "revise the present testing codes of the Society relating to boilers, pumping engines, locomotives, steam engines in general, internal combustion engines, and apparatus and fuels therefor, and to extend these codes so as to apply to such power generating apparatus as the present codes do not cover, including water-power, bringing them into harmony with each other and with the best practice of the day." This committee has just recently turned in its report, and among other things suggest the following rules for conducting tests of waterwheels, steam turbines and turbo-generators. These being of considerable interest to our readers, we are pleased to reprint them.

Rules for Conducting Tests of Waterwheels.

Introduction.—Waterwheel tests may be divided into two classes, one of which may be termed "shop" tests and the other "field" tests. The former refer to those which are conducted in a plant devoted exclusively to testing work, and the latter to tests of the wheel in its permanent location. The Holyoke Water Power Company's testing flume is an example of a shop-testing plant, being one which is equipped for turbine waterwheels of any size up to 300 h.p. at 18-ft. head. This plant, it is understood, is also at present the only one of the kind in the country which is available for commercial work. Under these circumstances there seems to be no call at the present time (1915) for a general code of rules applying to tests of that character. The tests to which the following code refers are, therefore, limited to field tests, the wheel being in place, and operating, so far as possible, under the conditions of service for which it was installed.

Object and Preparations.—The usual object of a waterwheel test in the field is the determination of the capacity and efficiency of the wheel at various gate openings, and, if practicable, at vaious speeds, as compared with standard or guaranteed performance. Having determined the object, whatever it may be, take the dimensions, note the physical condition of the wheel and of the plant throughout, install the testing appliances, etc., following the general instructions given in ¶ 1 to 20, so far as they pertain to the work in hand, and make preparations for the test accordingly.

The most important preparations are those which relate to the determination of the power developed by the wheel, and the quantity of water which it consumes. The nature of these preparations is governed altogether by the character of the equipment. As regards power determination, the simplest method is the one applying to a case where the wheel drives an electric generator and the power is measured by calculation from the electrical output. Another simple method is one which may be used where the wheel serves as an auxiliary to steam power, and the load is reasonably constant, in which case the output is determined by ascertaining the difference between the indicated horse-power developed by the engine when the wheel is on and that developed when the wheel is off. Another method which is applicable to almost any situation where there is room, although the most difficult of the three, is the use of a friction brake attached to the waterwheel shaft, being arranged so as to take the place of a section of the shaft which may temporarily be removed. As to preparation for water measurement, the desirability of preserving the maximum head of water usually makes it necessary to gauge the stream supplied to the wheel or the stream leaving it, and to select or prepare for this purpose a sufficient length of canal having a uniform cross-section to determine the required velocity by float measurement. Another method consists in the use of current meters or pitometers which have been properly calibrated. In cases where some part of the head may be sacrificed either in the head race or tail race, the measurement may be made by the insertion of a suitable weir.

Apparatus and Instruments.—The apparatus and instruments required for a capacity and efficiency test of a waterwheel are:—

(a) A friction brake, steam engine indicators, or electrical instruments, depending on the character of the equipment.
(b) Graduated scales showing the heights of water in the flume above the wheel and in the discharge pit beneath.
(c) One or more current meters or other apparatus for ascertaining the velocity of the water; or a weir.

Directions for the use of these appliances may be found in ¶ 9 and in Appendices Nos. 18, 19, 21, and 5.

It is of the greatest importance that the water measured is that which is consumed wholly by the wheel. If water leaks by without going through the wheel, the quantity of leakage should be determined by independent measurement when the wheel is entirely shut off, in which case the gross quantity is corrected accordingly.

Duration.—The duration of a simple efficiency test of a waterwheel depends mainly upon the method of water measurement employed, and the time required to obtain a sufficient number of observations to insure a reliable average. After the desired load and other conditions have been obtained, continuous observations and measurements for a period of 15 minutes is sufficient for all practical purposes, provided the water is measured by a weir, but a longer time is necessary when other methods of measurement are used.

Records.—The records should be obtained in a manner conforming to the principles explained in ¶ 15 to 18. Readings of the weight on the brake-arm, levels of water in the flume and discharge-pit, indications of the current meters, and revolutions per minute, should be taken every five minutes, and at more frequent intervals if they show much fluctuation. In case of float measurement, repeated observations should be made one after the other throughout the whole period of the trial.

Calculation of Results.—The total average head of water on the wheel is obtained by adding together the reading of the scale in the flume and the vertical distance between the zero of this scale and that of the scale in the discharge-pit, and subtracting the reading of the latter scale, both readings being taken in reasonably still water. The velocity of water in the measuring canal is found by averaging the readings obtained at several points extending over the whole width of the canal. The cubic feet of water flowing per second is obtained by multiplying the cross-section of the stream in square feet by the velocity of the water in feet per second, determined as stated above. The total power of water available is obtained by multiplying the net weight of water in pounds discharged per second by the total average head in feet on the wheel, and dividing the product by 550. The brake horse-power developed by the wheel is

found by multiplying the net weight on the brake-arm in pounds by the circumference of the corresponding circle in feet and by the number of revolutions per minute, and dividing the final product by 33,000.

In the case of a wheel supplied through a penstock the head is found by adding together the pressure at the intake to the wheel case, the velocity head at this point, and the elevation of the point above the surface of the tail water, all expressed in feet.

In an impulse wheel, the head is the sum of the pressure at the nozzle, in feet and the velocity head at that point in feet.

Data and Results.—The data and results should be reported in accordance with the form given herewith (Table 21), adding lines for data not provided for or omitting those not required, as may conform with the object in view:—

Table 21.—Data and Results of Waterwheel Test Adapted to Brake Measurement of Power.

Code of 1915.

(1) Test of............water wheel located at.............
To determine ....
Test conducted by...................................
(2) Type of wheel and class of service....................
(3) Type of generator, if any, kind of current, etc..........
(4) Rated power of wheel............................h.p.
(5) Cross-section of stream where velocity of water is measured ....sq. ft.

GENERAL DATA

(6) Date ....
(7) Duration of period covered by test................hr.
(8) Average net weight on brake arm..................lb.
(9) Average revolutions per minute.................r.p.m.
(10) Total average head of water on wheel..............ft.
(11) Average velocity of water per second in measuring canal ....ft.
(12) Volume of water flowing per second............cu. ft.
(13) Weight of water flowing per second (Item 12 × 62.35) ....lb.
(14) Leakage per second...............................lb.
(15) Net water discharged by wheel per second (Item 13 – Item 14) ....lb.

POWER.

(16) Total power of water available....................h.p.
(17) Brake horsepower developed by wheel..........br. h.p.

EFFICIENCY.

(18) Efficiency of wheel, (Item 17 ÷ Item 16) × 100..per cent.

Rules for Conducting Tests of Steam Turbines and Turbo-Generators.

Introduction.—The code for steam turbine tests applies to tests for determining the performance of the turbine alone, apart from that of steam-driven auxiliaries which are necessary to its operation. For tests of turbine and auxiliaries combined, and tests of turbines from which steam is withdrawn for heating feed water or other purposes, refer to the Code for Complete Steam Power Plants, Part IX. For methods of conducting tests of generators, motors, etc., and for general information bearing on the subject, reference may be made to the Standardization Rules of the A.I.E.E.

Object and Preparations.—Determine the object of the test, take the dimensions and note the physical conditions not only of the turbine, but of the entire plant concerned, examine for leakages, install the testing appliances, etc., as pointed out in the general instructions given in * ¶ 1 to 33 and prepare for the best accordingly (as given in the pamphlet report covering this subject).

Apparatus and Instruments.—The apparatus and instruments required for a performance test of a steam turbine or turbo-generator are:—

(*a*) Tanks and platform scales for weighing water, (or water meters calibrated in place).
(*b*) Graduated scales attached to the water glasses of the boilers.
(*c*) Pressure gages, vacuum gages, and thermometers.
(*d*) Steam calorimeter.
(*e*) Barometer.
(*f*) Tachometer, revolution-counter, or other speed-measuring apparatus.
(*g*) Friction brake or dynamometer.
(*h*) Volt meters, ammeters, wattmeters, and watt-hour meters for the electrical measurements in the case of a turbo-generator.

*Directions regarding the use and calibration of these particular appliances are given in ¶ 7 to 9, and in ¶ 24 to 33.

The determination of the heat and steam consumption of a turbine or turbo-generator should conform to the same methods as those described in the Steam Engine Code, Part V.

If the steam consumption is determined from the water discharged by the wet vacuum or hot-well pump, correction should be made for water drawn in through the packing glands of the turbine shaft, for condenser leakage, and for any other foreign supply of water.

Operating Conditions.
Duration.
Starting and Stopping.
Records.
Calculation of Results.

The rules pertaining to the subjects, Operating Conditions, Duration, Starting and Stopping, Records, and Calculation of Results, are identically the same as those given under the respective headings in the Steam Engine Code, ¶ 71 to 77, with the single exception of the matter relating to indicator diagrams and results computed therefrom; and reference may be made to that code for the directions required in these particulars.

Data and Results.—The data and results should be reported in accordance with the form (Table 11) given herewith, adding lines for data not provided for, or omitting those not required, as may conform to the object in view. If a shorter form of report is desired, the items in fine print designated by letters of the alphabet, may be omitted; or if only the principal data and results are desired, the subjoined abbreviated table (Table 12) may be used. Unless otherwise indicated, the items should be the averages of the data.

Table 11.—Data and Results of Steam Turbine or Turbo-Generator Test.

Code of 1915.

(1) Test of...............turbine located at.............
To determine.......................................
Test conducted by...................................

DIMENSIONS, ETC.

(2) Type of turbine (impulse, reaction, or combination) .
(*a*) Number of stages...............................
(*b*) Condensing or non-condensing....................
(*c*) Diameter of rotors..............................
(*d*) Number and type of nozzles......................
(*e*) Area of nozzles.................................
(*f*) Type of governor................................
(3) Class of service (electric, pumping, compressor, etc.) .

(4) Auxiliaries (steam or electric driven).
[illegible] equipment
Rated capacity of condensing equipment......
Type of oil pumps (direct or independently driven).
Type of exciter (direct or independently driven).
Type of ventilating fan, if separately driven...

(5) Rated capacity of turbine............................
(a) Name of builders............................

(6) Capacity of generator or other apparatus consuming power of turbine...........................

DATE AND DURATION.

(7) Date ....
(8) Duration .hr.

AVERAGE PRESSURES AND TEMPERATURES.

(9) Pressure in steam pipe near throttle by gage ....lb. per sq. in.
(10) Barometric pressure....................in. of mercury
(a) Pressure at boiler by gage........lb. per sq. in.
(b) Pressure in steam chest by gage....lb. per sq. in.
(c) Pressure in various stages.........lb. per sq. in.

(11) Pressure in exhaust pipe near turbine, by gage ....lb. per sq. in.
(12) Vacuum in condenser...................in. of mercury
(a) Corresponding absolute pressure..lb. per sq. in.
(b) Absolute pressure in exhaust chamber of turbine.................lb. per sq. in.

(13) Temperature of steam near throttle...............deg.
(a) Temperature of saturated steam at throttle pressure ....deg.
(b) Temperature of steam in various stages, if superheated ....deg.

(14) Temperature of steam in exhaust pipe near turbine..deg.
(a) Temperature of circulating water entering condenser ....deg.
(b) Temperature of circulating water leaving condenser ....deg.
(c) Temperature of air in turbine room........deg.

QUALITY OF STEAM.

(15) Percentage of moisture in steam near throttle, or number of degrees of superheating ....per cent. or deg.

TOTAL QUANTITIES.

(16) Total water fed to boilers.........................lb.
(17) Total condensate from surface condenser (corrected for condenser leakage and leakage of shaft and pump glands)...................................lb.
(18) Total dry steam consumed (Item 16 or 17 less moisture in steam)..............................lb.

HOURLY QUANTITIES.

(19) Total water fed to boilers or drawn from surface condenser per hour.............................lb.
(20) Total dry steam consumed for all purposes per hour (Item 18 ÷ Item 8)..............................lb.
(21) Steam consumed per hour for all purposes foreign to the turbine (including drips and leakage of plant) ....lb.
(22) Dry steam consumed by turbine per hour (Item 20 — Item 21) ....lb.
(a) Circulating water supplied to condenser per hour ....lb.

HOURLY HEAT DATA.

(23) Heat units consumed by turbine per hour [Item 22 × (total heat of steam per pound at pressure of Item 9 less heat in 1 lb. of water at temperature of Item 14)]............................B.t.u.
(a) Heat converted into work per hour........B.t.u.
(b) Heat rejected to condenser per hour (Item [illegible]) (approximate) ....B.t.u.
(c) Heat rejected in the form of steam withdrawn from the turbine...............B.t.u.
(d) Heat lost by radiation from turbine, and unaccounted for ....B.t.u.

ELECTRICAL DATA.

(24) Average volts, each phase........................volts
(25) Average amperes, each phase. ....amperes
(26) Average kilowatts, first meter.......................kw.
(27) Average kilowatts, second meter.....................kw.
(28) Total kilowatts output..............................kw.
(29) Power factor ....
(30) Kilowatts used for excitation, and for separately driven ventilating fan..............................kw.
(31) Net kilowatt output.................................kw.

SPEED.

(32) Revolutions per minute.........................r.p.m.
(33) Variation of speed between no load and full load ....r.p.m.
(34) Momentary fluctuation of speed on suddenly changing from full load to half-load..........r.p.m.

POWER.

(35) Brake horsepower, if determined........... .br. h.p.
(36) Electrical horsepower ....e.h.p.

ECONOMY RESULTS.

(37) Dry steam consumed by turbine per br. h.p.-hr......lb.
(38) Dry steam consumed per net kw-hr................lb.
(39) Heat units consumed by turbine per br. h.p.-hr. (Item 23 ÷ Item 35) ....B.t.u.
(40) Heat units consumed per net kw-hr..............B.t.u.

EFFICIENCY RESULTS.

(41) Thermal efficiency of turbine (2546.5 ÷ Item 39) × 100 ....per cent.
(42) Efficiency of Rankine cycle between temperatures of Items 13 and 14...................per cent.
(43) Rankine cycle ratio (Item 41 ÷ Item 42)...............

WORK DONE PER HEAT UNIT.

(44) Net work per B.t.u. consumed by turbine (1,980,000 ÷ Item 39) .. . . Ft.-lb.

Table 12.—Principal Data and Results of Turbine Test.

(1) Dimensions ....
(2) Date ....
(3) Duration ....hr.
(4) Pressure in steam pipe near throttle by gage ....lb. per sq. in.
(5) Vacuum in condenser ....in. of mercury
(6) Percentage of moisture in steam near throttle or number of degrees of superheating ....per cent. or deg.
(7) Net steam consumed per hour.........................lb.
(8) Revolutions per minute.......................r.p.m.
(9) Brake horsepower developed...................br.h.p.
(10) Kw. output ....kw.
(11) Steam consumed per brake h.p.-hr..................lb.
(12) Heat consumed per brake h.p.-hr.................B.t.u.
(13) Steam consumed per kw-hr...........................lb.
(14) Heat consumed per kw-hr........................B.t.u.

The MacArthur Concrete Pile and Foundation Co., of New York, have announced the removal of their office to the Equitable Building, 120 Broadway, New York.

Fred. L. Macpherson, municipal engineer, of Burnaby, B.C., laid 1,500 sq. yds. of waterbound macadam, scarified and oiled 15,000 sq. yds., and oiled 150,000 sq. yds. of macadam during the year 1915. Total pavements laid to date are 78,000 sq. yds. of asphaltic concrete and 175,000 sq. yds. of waterbound macadam. During 1916 it is planned to lay 6,000 sq. yds. of waterbound macadam and to do about the same amount of scarifying and oiling as was done last year.

WIDTH AND ALLOCATION OF SPACE IN ROADS.*

By F. Longstreth Thompson, B.Sc., Assoc.M.Inst.C.E.

In approaching the subject of "the width and allocation of space in roads" one is at once struck by the impracticability of attempting too much in the way of standardization. There is such a large diversity, for instance, in what may be termed the "quality" of traffic, that two roads carrying the same number of vehicles may require quite different widths. As an illustration of what I mean, take the heavy and slow moving traffic in a road serving the docks, and compare it with an equal volume of fast moving motor traffic on an ordinary road; the latter will only require about a third of the width necessary for the former.

Collection of Statistics.—It will be appreciated, therefore, at the outset that a careful classification of roads is needed, having as the chief consideration the prevailing type of traffic, and secondly, the volume of such traffic. A great deal of preliminary investigation is required in order to obtain accurate statistics for both the classification and subsequent design.

A certain amount of work of this kind has been done in more or less isolated cases up and down the country, and the investigations of the London Traffic Branch of the Board of Trade made for some of the principal London streets afford a valuable example of the method in which these inquiries should be conducted.

Observations were made on weekdays in both summer and winter, which showed that while there was considerably more passenger traffic in summer, the commercial traffic remained fairly steady throughout the year.

The fluctuations in volume during the day were, of course, very marked in and near the city, where the full stream of the morning influx and the evening exodus was felt, and the maximum volume was found to be on the whole about twice the average. Provision should be made in consequence for the maximum traffic.

The distinguishing between through and local traffic was found to be difficult of accomplishment, but this information is of the greatest importance, and some means of obtaining it must be found.

The mere number of vehicles passing does not afford sufficient data, and a scale of values was adopted, based on the amount of obstruction caused by the various types of vehicles, having regard to their size, speed and flexibility.

It is essential to assign values to the various classes of vehicle, for it is obvious that a heavy and slow moving goods lorry is a far greater obstruction, owing to its slowness and lack of flexibility, than, for instance, a taxicab, and the measure of the capacity of a street is therefore not its capacity of providing for such and such a number of vehicles, but for so many units of obstruction.

I have tried so far—very imperfectly, I know—to give a brief outline of the kind of data that it is desirable to collect for the purpose of determining the volume of traffic which has to be dealt with, and before I pass on to the use of this data in designing the road I would like to put in a plea for a systematic traffic census to be taken throughout the country twice a year—summer and winter. In this way we should accumulate statistics which would prove of inestimable value to town planners at a relatively insignificant cost.

*From a paper read at a meeting of the Town Planning Institute, held on March 10th, 1916.

Determination of Width.—While the great complexity of modern traffic—the mixture of fast and slow, cumbrous and flexible, local and through—makes it almost impossible to determine mathematically the utmost carrying capacity of a road, or conversely to calculate the necessary width for a given volume, it is possible from a consideration of—(1) The nature of the district, (2) the class of traffic, (3) the general importance of the traffic, (4) the observed volume of the traffic, to determine from general principles the number of lines of traffic to provide for, and hence the width of road to allow.

Provision must, of course, be made for the future, and it is here that the lack of reliable records handicaps us a good deal.

In our eagerness to avoid the costly mistake of underestimating future needs, we must guard against providing excessive width where it will never be required.

In this connection there is one very important safeguard in the hands of the town planner, which, however, requires careful and discriminating use.

It is possible—and indeed it should be the basis of design—so to plan the streets as regards position, direction, gradient, and width that the character of the street is definitely settled. Traffic streets should always be the widest, most direct, and best graded, and there should be no inducement for traffic to leave them and invade the quiet and seclusion of the residential roads.

The importance of settling the character of the street in this way can hardly be over-estimated.

It has the great advantage of enabling the designer to consecrate his energies on the provision of adequate width where it is certain to be wanted, and it furthermore has the most beneficial effect on the property fronting the various types of street, for where the character of the street is settled there is no risk of it being spoilt for its particular purpose, and its value is therefore assured.

This brings us at once to the need for classifying roads according to their use. They naturally divide themselves into two principal classes—traffic roads and residential roads.

Traffic roads lend themselves to sub-division under numerous headings, but it will be convenient to limit them to main avenues, main streets, secondary streets, local streets, boulevards and parkways.

Main Avenues.—The function of the main avenue is to form the chief artery by means of which traffic from one of the trunk roads of the country enters or leaves the city.

It will be desirable to provide for either a service of motor omnibuses, a surface tramway, or an underground tramway, or possibly some combination of these. My own personal feeling is that the motor omnibus will gradually oust the tramcar from the streets, and that tramways will develop much more on the lines of electric railways, and be located consequently either in a shallow subway under the road or, where space permits, in an open cutting.

Up till now it has been usual to allow at least one double track of tramway on the surface in proposals for main avenues, and the Advisory Board of Engineers to the Royal Commission on London Traffic, 1905, suggested that, in addition to a double track of fast trams in the centre of the road, there should be a line of stopping cars on each side, while they also provide a subway to take double tracks for both fast and slow electric trains. These proposals are perhaps excessive, and I think they might very well be limited to a double track for trains on the surface, and a subway with a double track for electric trains.

The number of lines of ordinary traffic which should be provided is essentially a matter which ought to be

decided on the merits of each particular case, but for purposes of comparison I have assumed that the streets considered under each of the headings are those of a large city.

There is a general consensus of opinion that for main avenues lined with shops or business premises four lines of traffic should be provided on each side of a central tramway. This allows for one line to be occupied by vehicles stopping at the curb, one by slow moving vehicles, and two by fast traffic.

Taking each line of traffic at a width of 8 ft., we get a total of 64 ft., to which must be added the tramway and the footpaths.

The width we can afford to allot to the tramway must depend entirely on the special circumstances of the case. Under any conditions, however, I think it desirable that the track should be definitely reserved for trams by means of a raised curb, and the minimum width allowable should be not less than 20 ft. Where it is possible to lay a sleeper track in grass between an avenue of trees it will be necessary to reserve a width of about 40 ft.

The customary allowance for footpaths is one-fifth of the total width on each side, but in the case of very wide roads this is unnecessary, and a width of 20 ft. seems to be a reasonable maximum.

It will be seen that we have a total width of 124 ft. between buildings, and I think we may regard this as a suitable width for a main avenue in a built-up area.

In districts not yet fully developed, where it is possible to secure a greater width without undue expenditure—as, for instance, under the provisions of a town planning scheme, there will be greater opportunities of providing for the amenities, and many variations suggest themselves.

Whatever allocation is adopted, however, I feel convinced that one or two guiding principles should be rigidly adhered to.

In the first place, fast traffic should be located as far as possible from those parts of the road devoted to foot passengers, in order that the noise, dust, and sense of unrest inevitably associated with fast moving vehicles shall disturb pedestrians as little as may be.

In the second place, tramways, whether they are placed towards the sides of the road or in the centre of it, should have a track entirely to themselves. This secures not only much more efficient working of the trams, but it also conduces in a very pronounced way to the safety and comfort of the other traffic.

In the third place, the indiscriminate use of trees and grass is to be guarded against.

If trees are to be used successfully, they must form a definite part of the street picture, either as a foil to the architecture, or for the purpose of affording shade, or protection from noise and dust. Nothing can be more unsatisfactory than trees badly placed, or planted under conditions such as insufficient space or too smoky an atmosphere, where they have not a chance to grow properly and quickly become an eyesore.

Much the same argument applies to turf; if rightly placed, under conditions where it flourishes and is well looked after, it is a continual source of delight, but where these conditions do not obtain it is far better to use gravel.

Main Streets.—These include those streets which, though of first-rate importance, do not fall within the category of main avenues.

It is impossible to lay down hard and fast definitions of the various classes, but perhaps the best description in this case would be those streets which form the main traffic routes within the city itself.

They form a group of hardly less importance than main avenues, and much the same considerations govern their design.

The probabilities are, however, that the available space will be more restricted, though, on the other hand, the traffic to be provided for may be rather less.

Provision for three lines of traffic on each side of a double tramway track will not be by any means excessive, and taking this as a reasonable standard, together with two footpaths each 18 ft. wide, a total width of 104 ft. is arrived at.

We are again confronted with the problem of deciding whether to provide an electric railway under the street, and on the whole I think it would be wise to do so.

In any case, I think we shall all be agreed on the necessity for providing adequate subways for the various mains, which all need attention at frequent intervals, to the great inconvenience of the general public, when, as is usually the case, it necessitates taking up portions of the footpath or carriageway.

An alternative arrangement is where the trams are placed at the side of the road, but this has the grave disadvantage that persons alighting from vehicles drawn up at the curb have to cross the track in order to reach the footpath.

There is no little danger, I think, when one is endeavoring to arrive at some sort of a standard width for any type of road that a nightmare of uniformity may be the result.

This is so far removed from the ideals of a town planner that it is more than ever necessary to urge that the object aimed at is not a standardization of roads, but a standardization of the principles of design.

In this connection we have a very important problem before us. For, whereas there is a fairly general agreement amongst traffic experts that a width of about 100 ft. is a proper allowance for main streets in cities, we have a totally different opinion expressed by men with a large experience of retail trade.

All the gentlemen who kindly let me know their views as to the general requisities of a shopping street agreed that main traffic streets offered the best opportunities for shops. They wish, however, to limit the width—in the interests of shopping—to from 50 to 70 ft.

A compromise might be accomplished by abolishing the surface tramway and replacing it by an underground tramway, probably in conjunction with motor buses. A further economy in width is realized by a strict relegation of all delivery vans to a service road in the rear of the shops, while a footpath 18 ft. in width would allow of frequent bays for the accommodation of vehicles wishing to draw up and deposit passengers.

Secondary Streets.—These may be said to form the connecting links in the system of main streets. They probably will not deal to any extent with through traffic, but are likely to carry a considerable volume of local or semi-local traffic.

A few, acting as supplementary ring roads within the city, will require tramway tracks, but as a general rule it may be taken that these will not be necessary.

In no other class of street perhaps does the width and allocation of space depend so much on the particular needs of the locality, and a large number of variations are possible.

The definition of secondary streets is necessarily more elastic than in the other classes, with the exception of boulevards or parkways, and widths have been proposed varying from 60 ft. to 80 ft.

A width of about 40 ft. will be sufficient for local streets, which provides for two footpaths each 8 ft. wide and carriageway of 24 ft.

Boulevards and Parkways.—In the design of boulevards the town planner has perhaps his greatest opportunity of providing for the city a feature distinctive in character, useful in purpose, and an unbounded source of delight both to the visitor and the thousands of people who daily make it their promenade.

One very important point to be borne in mind in the design of boulevards is that they should connect up and form part of the park system. This consideration will lead to a generous allocation of space to the park-like features, which will undoubtedly result in a much greater use of the parks themselves than is the case when they are separated by tracts of uninviting bricks and mortar.

Residential Roads.—It has been urged in the earlier part of this paper that the provision of wide roads should be limited to the traffic routes, and that these should be made *so good* that there is no inducement for traffic to leave them and invade the privacy of residential roads.

Now, we have ample evidence that this principle has not been followed in the past, and the result has been an unscientific and ugly uniformity, together with an overcrowding of houses upon the land.

The Housing and Town Planning Act, however, comes to our assistance in this respect by giving the local authority power to vary by-laws in the provision of a town planning scheme, and, as is well known, substantial reductions from the by-law width in the case of short streets are actually in force under the Ruislip-Northwood scheme.

With proper safeguards as to the limitation of the number of houses to the acre, the proportion of curtilage which may be occupied by buildings, suitable building lines, and a restriction on the height of the buildings, I think we may look forward to much more reasonable requirements as regards the width of the roads. In addition to the relaxation of the by-law width, however, considerable freedom should be allowed both in the design and construction of residential roads.

There is room for almost every kind of treatment, from the glorified carriage drive to the formal square, and it may be said, I think, with some truth that the only really guiding principle should be to make each road suitable to the property it serves.

One hesitates to make suggestions in regard to a subject where generalizations serve no useful purpose, but a few notes may not be altogether out of place.

In a high-class residential district where there are few houses and large gardens, traffic is reduced to a minimum, and it will be possible to make use of a narrow road possessing something of the characteristics of a carriage drive. One footpath will be ample, and the trees should be planted on the garden side of the hedge.

On roads having a crossfall an economy can be practised and a charming effect produced by keeping the footpath at a higher level than the carriageway.

In the development of smaller class property, including that occupied by the working classes, the houses are necessarily much closer together, and consequently the roads will be busier.

Here much can be done by careful planning, so that one fairly wide road may serve a large area developed by means of smaller roads, drives, closes, and so forth.

These minor roads can quite suitably dispense with a footpath altogether, and examples are in existence at Earswick, Letchworth, and other places, where this has been done with most happy results. Where vehicles use roads of this type a minimum width of 18 ft. should be provided.

As regards the design of formal residential roads, I do not propose to say more than that they should form a definite part of the architectural scheme. The proportion of the width allotted to the footpaths and planted strips will naturally be greater, and that for vehicles less, than is the case for streets of similar dimensions designed for traffic.

BUILDING A DEEP-WATER CONCRETE PIER ON SHORE AT VICTORIA, B.C.

THE development now in progress of the Victoria, B.C., harbor involves the construction of about 5,000 ft. of pier and dock facing, which consists of sectional hollow concrete wall, 35 ft. wide and 39 ft. high. Each section is an 80 x 35 x 39-ft. concrete caisson, with reinforced outer walls 20 in. thick on all sides and seven intermediate 10-in. transverse walls. It has a solid bottom, thus forming a 2,500-ton caisson with eight separate compartments.

Concrete Plant.—The floating concrete plant is installed on a 40 x 120-ft. scow, and has large elevated storage hoppers, from which sand and gravel are discharged by gravity to measuring-boxes below deck that deliver their contents by an endless belt and bucket conveyer to the mixer hopper. Cement is charged into an iron receptacle in the cement house and forced by compressed air through a 4-in. pipe to the mixer hopper.

Concrete is discharged from the mixer to a skip, which is hoisted to the top of a 120-ft. tower and distributed by a pipe to any point of the caisson form.

Drydock Construction Attempted.—The first two of the fifty-four caissons were built in a floating drydock, which, with the caisson, weighed about 6,000 tons. While attempting to launch the caissons from the drydock the latter canted so much as to cause the caissons to slip transversely, overturning and wrecking the drydock. The caissons were subsequently recovered, floated three miles to the required site, and successfully sunk to position. No further attempts were made to use a drydock for the caissons.

Handling Caissons on Rolling Platforms.—A 90 x 225-ft. wooden pile skeleton pier has been built in water about 40 ft. deep, six miles from the pier site, and here five caissons are constructed at once on separate 40 x 100-ft. beds rolling on 4-in. double-flange cast-iron rollers, spaced 10-in. centres on 12 lines of 8 x 1-in. track rails.

The finished caissons are successively pulled transversely on to the launching cradle by two 13-part tackles, rove with ¾-in. wire rope and operated by 7 x 10-in. hoisting engines.

The launching cradle is a ballasted wooden scow about 90 ft. long, 38 ft. wide and 7 ft. deep at the lower end, the bottom inclined to match the 1 : 18 slope of the pile trestle ways, 700 ft. long. The cradle is set on 4-in. double-flange cast-iron rollers on seven lines of 7 x 1-in. track rails, and before launching is held in position by four 8 x 1-in. anchor straps.

At the beginning of the launch, the caisson moves by gravity and is held back by a 29-part wire rope tackle operated by a 10 x 12-in. hoisting engine. Near the foot of the launching ways the caisson having developed retarding buoyancy, has to be pulled down by an auxiliary 7 x 10-in. hoisting engine. This plant has a capacity of one caisson every seven days. It was designed, constructed and operated by Grant Smith & Co. & McDonnell.

THE DISCHARGE FROM VERTICAL PIPES.*

By C. E. Grunsky.

WHILE assistant state engineer of California from 1881 to 1888, I had to examine many artesian wells and found it necessary early in this experience to devise a formula that would enable a quick estimate of discharge, using as basic elements the diameter of the well and the height to which the outpouring water rose above the top of the well-casing.

The formula which proved satisfactory was made public in a paper read before the Technical Society of the Pacific Coast on October 3, 1884, and has not, so far as I know, been superseded by anything better. Although the formula was based on but few experiments, it is fairly dependable when applied to wells that are four inches or more in diameter, and may be equally so for smaller wells, but on this point I have no information.

Let D = discharge in cu. ft. per second.
d = inside diameter of the casing in feet.
*h_0 = height in feet to which water rises in the centre over the top of the casing.

Then as originally written:

$$D = \frac{10d\sqrt{h_0^3}}{\sqrt{1 + 2.525\left(\frac{h_0}{d}\right)^2}} \qquad (1)$$

$$\text{or } D = 10d\sqrt{\frac{h_0^3}{d^2 + 2.525h_0^2}} \qquad (2)$$

$$\text{or } D = 10d^2\sqrt{\frac{h_0}{\left(\frac{d}{h_0}\right)^2 + 2.525}} \qquad (3)$$

When h_0 is small in comparison with d, the denominator in (1) approaches unity, and, with sufficient accuracy for the special case in which the rise of the water above the top of the casing is less than one-tenth of the diameter of the casing, the formula may be written

$$D = 10d\sqrt{h_0^3} \qquad (4)$$

and the similarity of the formula to that for a sharp-edged weir will be recognized.

If in this formula the length of the weir crest $3.1416d$ be introduced it will be seen that

$$D = (3.18d)(3.1416)\sqrt{h_0^3}$$

whereas the well-known Francis weir formula would make, for the special case under consideration,

$$D = (3.33d)(3.1416)\sqrt{h_0^3}$$

The formulæ (1), (2), (3), and (4) are applicable to the flow from vertical pipes, of wrought iron or other thin material such as ordinarily used for well-casing.

When h_0 is small, overfalling water may adhere to the outside surface of the casing. In this event before h_0 is measured the water film must be broken and air admitted under the overfalling sheet of water. To measure h_0 a thin scale, with knife edge, may be used. The measurement is made at two points at the opposite end of a diameter with the scale held radially so as to offer least obstruction. Care must be taken to sight for both readings in the same horizontal plane. The top of the water dome will generally be undulating and the observation should continue long enough to get its mean elevation and not the extreme momentary rise of the water at the centre. The value of d is the mean of two inside diameters at right angles to each other.

The well-borer's practice, when he has finished his work, is to wet a saw-blade, cover the same with fine sand or dust and place the same back down, on edge across the top of the casing. The extreme height of the sand washed off is his estimate of the rise of the water above the top of the casing. This method of determining h_0 would give too large a value and is not, therefore, advisable when the formula is to be applied.

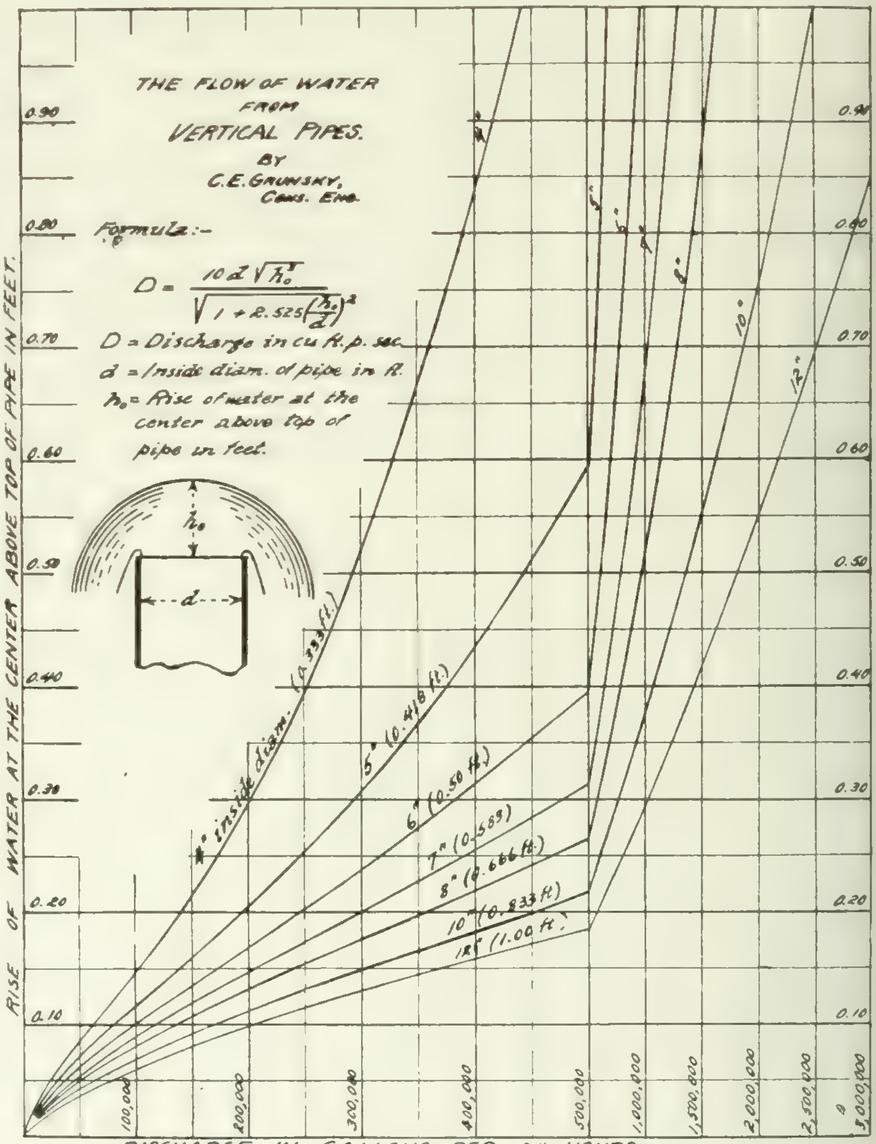


Chart for Computing Discharge.

Example: What is the flow in gallons per 24 hours of an 8-in. artesian well in which the water is found to rise 3 ins. (0.25 ft.) above the top of the casing?

Let it be supposed that the average of the two diameters which were measured is exactly 8 ins., then:

$$\frac{d}{h_0} = 2.667 \text{ and } \left(\frac{d}{h_0}\right)^2 = 7.11$$

$$D = 10 \times 0.667 \times 0.667\sqrt{\frac{0.25}{7.11 + 2.525}}$$

D = 0.715 cu. ft. per second = 460,000 gallons per 24 hours.

*Abstract from a paper published in the Transactions of the Technical Society of the Pacific Coast.

USE AND CARE OF EXPLOSIVES.*

By Dr. R. E. Somers,
Department of Geology, Cornell University.

EXPLOSIVES are divided into two classes which may be designated simply as low explosives and high explosives. As an example of the former, there is ordinary black powder, or gunpowder, and among the latter are the dynamites, blasting gelatine, gelatine dynamites, picric acid and other nitro-explosives.

This difference in explosive power is due to the way in which the two essentials of the explosive reaction, namely, the material which oxidizes or burns, and that which furnishes the oxygen for the combustion, are combined. Gunpowder, for instance, is simply a mechanical mixture of charcoal, sulphur, and potassium or sodium nitrate. The charcoal and the sulphur burn, while the nitrate furnishes the oxygen for burning. In an explosive like dynamite, however, the constituents are not mixed mechanically, but are combined chemically, so that the material that burns, and the material that furnishes the oxygen are bound together in a chemical compound. It is small wonder, then, that such an explosive as gunpowder should be of low power, while one like dynamite should be of high power.

Incidentally, nitroglycerine, one of the high explosives, is made by the action of nitric acid on glycerine. When first made, in 1847, it was found to be very sensitive to shock and friction, and as a result they set about finding some way to get the explosive effect of nitroglycerine without so much danger in handling it. In order to get that result, Alfred Noble in 1865 hit upon the idea of absorbing it in something porous, like diatomaceous earth, a cellular siliceous powder, and by means of this absorption, cushioning the sensitive nitroglycerine enough to reduce the dangers of handling it, while at the same time retaining most of its explosive power. This mixture was called dynamite. The absorber is called the "dope," and while the first dope was diatomaceous earth, the ones used now are such as sawdust, wood meal, or a nitrate of potassium or sodium, which burn at the moment of explosion and thereby utilize the small amount of oxygen set free by the combustion of the nitroglycerine.

Guncotton is selected cotton, acted upon by nitric acid. It is usually compressed because it explodes better in that condition, and is the basis of many military explosives.

Blasting gelatine and the gelatine dynamites are often used in engineering and contracting work. The former is made by dissolving a small quantity of soluble guncotton in nitroglycerine and gelatinizing the solution in such a way that the dangers of handling it are somewhat reduced. This gelatine may then be absorbed in sawdust or some other dope giving a gelatine dynamite.

Contractor's powder consists of a small quantity of nitroglycerine absorbed in gunpowder as a dope. In a way, therefore, it possesses intermediate properties between the two.

In considering the care necessary in handling explosives, the two classes must be treated separately. Gunpowder, or black powder, is not sensitive to shock, percussion, or friction. Therefore it is not necessary to be careful about dropping it, or to prevent the slightest friction in manipulating it. It is undoubtedly true that black powder can be exploded by striking it, on an anvil, with a hammer, metal upon metal in other words, but except under such very extreme treatment it can be handled roughly with comparative safety. The principal thing about taking care of it is to keep it dry. A good idea of the condition of gunpowder may be gained by pouring out a small quantity on a sheet of white paper. When rolled from one part of the paper to another it should leave no dust. Dust is fine-grained, mealy powder that may have been left in the manufacture and serve to lessen the effects of the explosion, or it may be the result of moisture in the powder, which of course is a mark of deterioration. If this powder then be ignited, it should burn up without leaving a residue and without burning the paper. If black spots are left, it means that there is too much charcoal, or that the materials have been improperly mixed. Yellow spots indicate an excess of sulphur. If holes are burned in the paper, the powder is too moist. Although affected by moisture, it may still be brought back to good condition by drying, unless there are white spots on the grains. These indicate that the nitrate has leached out because of the moisture, and that the powder is practically spoiled, as far as getting the best efficiency out of it is concerned.

The high explosives, however, require much more careful treatment because of their sensitiveness. In the case of the dynamites, this is due to the sensitiveness of the nitroglycerine or the blasting gelatine from which they are made, and the cushioning by absorption in a dope is only partially effective. The percentage by which a dynamite is designated refers to the percent. by weight of nitroglycerine or gelatine in the cartridge. The remainder is absorbent. Since, therefore, the lower grade of dynamites contain much more dope in proportion to explosive, than do the higher grades, the explosive itself is better cushioned, and the dynamite less sensitive. The higher grades, on the other hand, are cushioned to a less degree, and are apt to be much more sensitive. Thus, a dynamite of small percent. can be handled more freely and with less care than one of large percent.

Dynamites should be stored in a building separate from any habitation, so that in case of an accidental explosion there will be no further damage than to the building itself. The explosive must be kept dry. There should be no metal used in moving the boxes of explosive, or in opening them, because at times nitroglycerine may leak out of the cartridges into the wood of the boxes and if this should be struck by a steel wedge or chisel, an explosion would be very apt to follow. Copper wedges are safer than steel or iron, but wood is the best. No flame lights, such as lamps or candles, should be allowed in the storehouse. The building itself should be heavy enough to afford complete protection against the weather.

The condition of dynamite can be told fairly well by an inspection of the cartridges. There should be no greasy material on the outside of the paper, since its presence means that the nitroglycerine is leaking out and the dynamite is dangerous. The sticks should have no white spots on them. These indicate that sodium nitrate has been used in the dope, that it is absorbing water, which it does easily, and that it is leaching out on the surface, thereby decreasing the value of the material as an explosive. Furthermore, there should be no green color about the stick. Nitroglycerine, under certain conditions, decomposes, with the liberation of green nitrous oxide gas. Such decomposed nitroglycerine is very dangerous, and hence if there are any green spots on the outside of the stick or underneath the paper, the dynamite should be spread out on the ground, at a distance from any habitation, and burned.

The most important thing, however, in the handling of the high explosives, is the thawing of dynamite that has frozen. Dynamite, or the nitroglycerine in dynamite

*In Cornell Civil Engineer.

freezes at from [illegible] to [illegible] F., in other words, from [illegible] to [illegible] higher than water. Not only does it freeze thus easily, but when frozen it is very sensitive to breaking, percussion or friction, and yet cannot be exploded well in blasting. It therefore must be thawed, while at the same time the dangers of the operation are many. There have been very many accidents in thawing dynamites, due chiefly

Fig 1

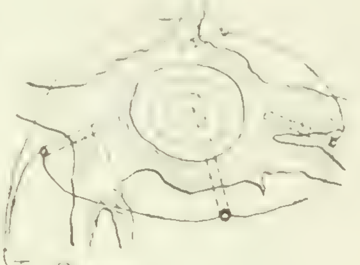


Fig 2

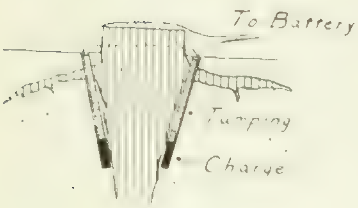


Fig 3

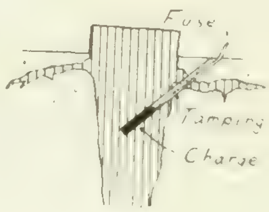


Fig 4

to the crude methods which have been employed. It is quite common to heat a flat stone in a fire, and then lay the stone off to one side and put the dynamite on it; ovens are filled with dynamite; a griddle is set off the stove and the sticks placed upon it; the sticks are laid on top of a boiler; they are put in hot water, or even thawed with a candle. Such methods are exceedingly dangerous, because they violate, in every case, two important principles. In the first place, nitroglycerine will leak out of dynamite when the latter is heated. Warm nitroglycerine is doubly sensitive and if a drop of it fall from the stick onto a stone, or stove, or kettle, an explosion is sure to result. In the second place, the dope has a greater affinity for water than for nitroglycerine, so that when dynamite is placed in water, especially if the latter has been heated, the water displaces the nitroglycerine, and forces it out of the cartridge. Again, there are liberated sensitive drops of a liquid that will explode upon the slightest provocation.

There are, however, many ways in which dynamite can be thawed with perfect safety and most of them consist of warming it, to a moderate degree, by means of hot water, but not in contact with it. Most of the thawing kettles put out by the explosives manufacturers consist of two compartments, one for the sticks of dynamite, and the other for the water that has already been heated. The kettles themselves should never be placed on a stove. A thaw house may be built, and kept at the right temperature by means of cans of hot water, or by hot water heaters.

In choosing an explosive for any blasting operation, it must be recognized that the different explosives have somewhat different behaviors. A low explosive, like gunpowder, has a comparatively slow, lifting or heaving action. It, therefore, is the proper explosive to use on clays or sands that are not consolidated. A high explosive, like dynamite, has a quick, shattering action, and the higher the grade of dynamite, the quicker its explosive effect. Consequently, a high explosive should be used on the consolidated rocks, and the harder the rock and the finer it needs to be broken up, the higher the grade of explosive that should be used.

There is not much that is to be said that is definite on the theory of blasting. The effects of an explosion are spent upon shearing the rock, lifting the rock and the air above it and heating the rock. Both the rocks, and the explosives themselves are extremely variable, and hence blasts are made under very widely varying conditions. It is therefore impossible to determine the quantitative effect of a unit weight of explosive, and formulate rules for the amount of explosive to use, and the depth and spacing of holes in any given instance. The best way is to profit from the experience of others on similar operations and to experiment with their quantity factors to make them fit the work at hand.

As an introduction to the latter part of my subject, namely, the use of explosives in highway construction, it would be well to note that there are proper as well as improper ways of priming a cartridge of dynamite. One end of the fuse should be cut off square and clean, and over that end the cap should be carefully placed. It should not be forced on if the fuse is too large, but the latter should be whittled to the right size. The cap should be crimped onto the fuse by means of crimping pliers, and never by means of the teeth. Then a hole is punched in the end or side of the cartridge with a wooden stick or with one of the handles of the crimper, the cap inserted, and the fuse tied to the cartridge with a string. This allows the primer to be lowered down the drill hole without danger of pulling out the cap, and is very much better than the half-hitch which many blasters make around the cartridge. In case an electric exploder is used instead of a fuse cap, the procedure is similar.

The principal uses to which the highway engineer may put explosives are, (1) the removal of stumps, (2) the breaking the boulders, (3) the removal of obstructing ledges and (4) the blasting of drainage ditches.

For the removal of stumps, holes should be bored underneath the stump by means of an earth auger. Figs.

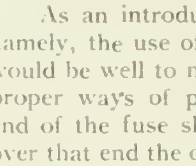


Fig 5

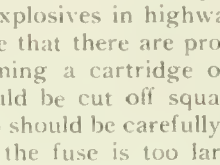


Fig 6

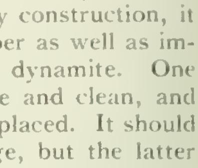


Fig 7

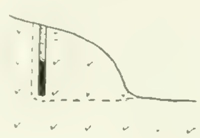


Fig 8

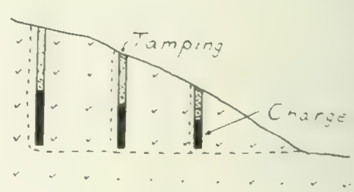


Fig 9

1-4 indicate the placing of these holes for stumps of different kinds and sizes. For a small stump, one hole is sufficient, as shown in Fig. 1. It should not be bored too flat, because the tendency then will be to split the stump rather than to tear it loose. In case of a large stump (Fig. 2) several holes should be bored. Where a tap root is to be removed, the holes may be placed as in Figs. 3 and 4. Dynamite of low or medium grade is used, and for a stump of moderate size one to three sticks are

sufficient, while for a large stump, such as shown in Fig. 2, from one to three sticks per hole are required. The last stick is primed with a fuse cap or an electric detonator, or cap, except in a case like Fig. 2, when it is necessary to fire all the holes simultaneously and electric firing is demanded. In any case the hole must be tamped.

There are three methods by which boulders may be broken up. The one illustrated in Fig. 5 is called blockholing. A hole is drilled about half-way through the boulder, charged with a small amount of medium to high-grade dynamite, primed with a fuse or an electric detonator, and well tamped. This is economical in powder consumption, and the best method where there are many boulders to blast. Fig. 6 illustrates mud-capping. One or two sticks, primed, are laid on the flat surface of the boulder, and a 6-inch thickness of mud or clay pitted down on top. This is a very handy method but uses explosives rather wastefully. Fig. 7 shows undermining, or the snake-hole method. A hole is bored under the boulder and charged with from one to three sticks of dynamite. This method requires an intermediate amount of explosives and labor.

Blasting to grade often requires the removal of projecting ledges and this may be accomplished by placing rows of holes as shown in Figs. 8 and 9, firing one row

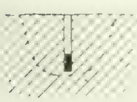


Fig 10

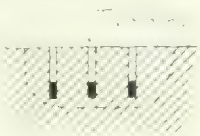


Fig 11

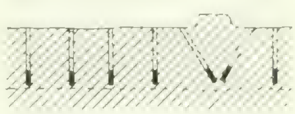


Fig 12

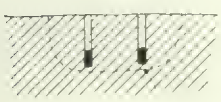


Fig 13

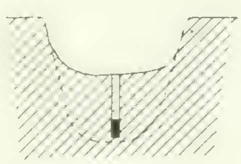


Fig. 14.

at a time, and thereby evacuating along the dotted lines shown. These holes should be placed a distance apart along the rows, and a distance back from the edge of the cut, equal to their depth, except when very deep, in which case they should be closer and nearer to the edge than their depth. They should be loaded from one-third to one-half of their lengths with low or high grade dynamite, according to the hardness of the rock. They should be well tamped, and should be fired by fuse or electricity.

By exploding one or more rows of vertical holes, drainage ditches may be blasted in soft materials. Figs. 10 to 14 show the way in which the holes are placed, Figs. 10, 11, 13 and 14 in cross-section, and Fig. 12 in longitudinal section. The holes should be about the same depth as the ditch desired, which, for Figs. 10-12, might be from 1½ to 5 feet deep. If greater depth is desired, the operation may be carried on as illustrated in Figs. 13 and 14. The holes should be from 1½ to 4 feet apart along the rows, charged with from one to three sticks of dynamite of medium or low grade, and fired simultaneously. Where the ground is actually saturated with water, this may be accomplished by one or two caps for each row of holes, but otherwise each hole should be primed.

In conclusion, if explosives are properly handled they are not especially dangerous, and there are many operations in road construction where their use means a saving of time, labor and materials.

CONCRETE PAVEMENTS IN CANADA.

In connection with the "Review of 1915 Paving Work," published in May 11th issue of *The Canadian Engineer*, it is of interest to note that "Concrete Roads," a new booklet that is now being distributed by the Canada Cement Co., Montreal, contains the following authentic list of concrete roads, lanes and streets laid during 1915 by Canadian towns and cities:—

Oshawa, Ont., 9,000 square yards; Leamington, Ont., 11,200; Essex, Ont., 6,430; Grimsby, Ont., 2,476; Ingersoll, Ont., 3,929; Bridgeburg, Ont., 16,960; Berlin, Ont., 2,083; Windsor, Ont., 20,111; Niagara Falls, Ont., 3,200; Fort Erie, Ont., 3,080; Sault Ste. Marie, Ont., 11,800; Walkerville, Ont., 5,168; Sandwich, Ont., 32,866; Ojibway, Sandwich and Sandwich West, 65,500; Chatham, Ont., 10,895; St. Thomas, Ont., 2,125; Cayuga, Ont., 1,907; Merritton, Ont., 2,835; London, Ont., 5,500; St. Catharines, Ont., 1,000; Toronto, Ont., 21,995; Toronto-Hamilton Highway, Ont., 196,520; Amherstburg, Ont., 5,000; Pointe du Lac, Que., 43,555; Cap Madeleine, Que., 25,805; Berthier, Que., 9,750; Three Rivers, Que., 50,633; Shawinigan Falls, Que., 10,000; Ste. Rose, Que., 11,000; Westmount, Que., 9,455; Steel Co. of Canada, 400; Harbor Commissioners, 9,760; LaSalle, Que., 2,347; Pointe aux Trembles, 11,436; St. Anne de la Perade, 1,774; Amherst, N.S., 17,439; St. Vital, Man., 37,480. Total, 682,414.

The following interesting tables are also contained in the above-mentioned booklet:—

Square Yards Concrete Highways in Canada (by Provinces).

Province	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alberta		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
British Columbia			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	147,042
Manitoba						[illegible]	[illegible]	[illegible]	[illegible]
New Brunswick						[illegible]			[illegible]
Nova Scotia						[illegible]	[illegible]	[illegible]	28,759
Ontario	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Quebec				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saskatchewan			[illegible]	[illegible]					[illegible]
Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Number of Municipalities in Canada that Have Used Concrete for Paving Surface.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Street	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
R[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	
[illegible]					[illegible]		
Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Edwin S. Fraser, town engineer of New Glasgow, N.S., states that 5,940 sq. yards of bitulithic were laid in 1915, and 8,200 yds. of concrete sidewalks. Total pavements laid to date are 11,100 sq. yds. of bitulithic. About $12,500 will be spent this year on new pavements. It is planned to lay about 6,000 sq. yds. of concrete.

The Barrett Co., of New York, has now issued a 20-year guaranty bond of all Barrett specification roofs of 50 squares or more in the United States and Canada in towns of 25,000 population and over, and in small centres where their inspection service is available, provided the roof is laid by a roofing contractor satisfactory to them and in strict accordance with the Barrett specification dated May [illegible], and subject to the inspection and approval of that company. This is a new departure and one which should be of great value to architects, engineers and owners of industrial plants of all kinds throughout the Dominion. This proposal on the part of the Barrett Co. has grown out of the conviction that with workmanship properly safeguarded, a Barrett specification roof should last for a minimum period of 20 years without repairs. The issuing of such a bond is evidence of the company's faith in their product.

PROGRAMME OF CONVENTION OF THE AMERICAN WATERWORKS ASSOCIATION, NEW YORK, JUNE 5th TO 9th.

We have pleasure in publishing herewith the programme of this very important function. Any of our readers who have attended the conventions of this body before will recall how exceedingly interesting and valuable the papers and discussions have proven. It is very much to be hoped that Canadian members of the Association will make a very special effort to attend. Convention headquarters will be at Hotel Astor, New York.

Monday, June 5th, will be devoted to registration, meetings of special committees, etc., and a general "getting together."

The real business of the convention will get away to a good start, Tuesday, June 6th, at 9 a.m. The forenoon will be spent listening to the president's address, addresses of welcome and responses thereto by the president of the Association, Nicholas S. Hill, Jr. The following papers will be delivered that afternoon: "Experience with a Card Consumer's Ledger,"* E. W. Haseltine. "Interpretation of Waterworks Accounts"* (with lantern slides), Mark Wolff.

Wednesday, June 7th.

Forenoon Session.—9 a.m.—Presentation of papers. "Difficulties in the Design and Operation of Medium-sized Waterworks Systems,"* E. B. Black. "Pumping Machinery: Test Duty versus Operating Results,"* J. N. Chester. "Reservoirs"* (presented with lantern slides), Dabney H. Maury. "Prevention of Water Waste on Railroads"* (lantern slides), C. R. Knowles. Report of Committee on Electrolysis, Prof. Albert F. Ganz, Chairman.

Afternoon.—Trip to Kensico Dam.—The Department of Water Supply, Gas and Electricity, the Board of Water Supply of the city of New York and the active members of the American Waterworks Association in the New York Section territory have arranged a trip to the Kensico Dam. A special train will leave the Grand Central Station at 1.30 p.m. for Valhalla Station, on the Harlem Division of the New York Central Railroad. Surface cars pass the hotel, running direct to the station. Returning, train will leave Valhalla about 4.45 p.m., arriving in New York about six o'clock, in time for dinner.

Evening Session.—8 p.m.—Election of Nominating Committee. Selection of place for holding the 1917 Convention. (Associate members vote on place for holding Convention.)

Presentation of Papers.—"Pressure Filters"* (presented with lantern slides), Harold C. Stevens. "The Typhoid Toll"* (presented with lantern slides), George A. Johnson.

Thursday, June 8th.

Superintendents' Day.—Forenoon Session.—9 a.m. —Question-box and discussion of waterworks topics. A special programme, with questions and topics for discussion, will be issued for this day.

Afternoon Session.—2 p.m.—Superintendents' Day continued to 3 p.m.

3 p.m.—Special examination of exhibits in exhibition room, with demonstrations. Organ recital in the exhibition hall from 3 to 6 p.m.

(Papers marked with an * are printed in the June Journal of the Association.)

Chemical and Bacteriological Section. Forenoon Session. — 9 a.m. — Presentation of papers. — "Some Aspects of Chlorination,"* Joseph Race. "The Mount Kisco Sewage Disposal Plant, Croton Watershed," Theodore DeLong Coffin and Frank E. Hale. "Some Problems of the State Water Laboratory," L. H. VanBuskirk. "Recovery of Spent Lime at the Columbus Water-softening and Purification Works," Charles P. Hoover.

Afternoon Session.—2 p.m.—"A New Raw Water Supply for the City of McKeesport, Pennsylvania," Edward C. Trax. "Tests for Bacillus Coli as an Indicator of Water Pollution," C. E. A. Winslow.

Evening.—8.30 p.m.—Informal reception and dance tendered to the president and delegates of the American Waterworks Association by the Waterworks Manufacturers' Association in the Hotel Astor. At 9.30 the award of prizes will be made to the Section of the American Waterworks Association having made the greatest gain in membership, and to the individual member of a Section having secured the largest number of members.

Friday, June 9th.

Forenoon Session.—9 a.m.—Presentation of Papers. —"The Selection, Installation and Test of a 1,000,000 Gallon Motor-driven Centrifugal Pump,"* S. R. Blakeman. "The Latest Method of Sewage Treatment"* (presented with lantern slides), Edward Bartow. "Copper Sulphate Treatment of St. Paul, Minnesota, Water Supply,"* Prof. N. L. Huff and Garrett O. House. Report of Committee on City Planning, Ernest P. Goodrich, chairman.

On Saturday, June 10th, the local committee of arrangements has made plans for excursions to various points of interest. Full particulars regarding the Convention, programmes, etc., can be secured by communicating with J. M. Diven, Secretary, Troy, N.Y.

C. H. Rust, city engineer of Victoria, B.C., states that $42,316 was spent by Victoria last year for 23,399 sq. yds. of sheet asphalt and 4,152 sq. yds. of asphaltic concrete. This amount included surface, base and grading. Approximately the same amount will be spent this year. Total pavements laid to date in Victoria are: Sheet asphalt, 54¾ miles; asphaltic concrete, ¼ mile; brick, ½ mile; concrete, ¾ mile; waterbound macadam, 12½ miles; bituminous macadam, 1½ miles; creosoted wood block, 3½ miles.

The difficulties experienced by trade, industry and agriculture in the forwarding of goods by rail were recently discussed at some length in the French Senate, when serious complaints were made of the long delays which are taking place. The causes of the crisis are the diminution in the quantity of rolling stock, as a result of the war, the defective circulation of the rolling stock, inadequate supply of labor, and the insufficient capacity of the sorting sidings, which were not prepared for war conditions. It appears that out of the total rolling stock in the country, 54,000 wagons were seized by the enemy, but as 3,000 German trucks were retained, and 7,000 Belgian wagons were available, the difference works out at 44,000 wagons. If to these are added approximately 20,000 wagons retained for military requirements, a total deficit of from 60,000 to 70,000 wagons exists. To remedy the matter, about 2,500 wagons are being obtained from England, which will release an equivalent number of French rolling stock, 24,600 new wagons have been ordered, and a further supply of 10,000 is in negotiation, all of which will be delivered in the present year beginning from this month. It is therefore expected that the difficulty will be progressively reduced, in conjunction with the improvements which are being effected in the circulation of the wagons.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Concrete on the Farm and in the Shop. By H. Colin Campbell, C.E. 128 pages, 5 x 7 ins., 51 drawings, cloth. Price, 75 cents.

This is a new book from cover to cover, illustrating and describing in plain, simple language many of the numerous applications of concrete within the range of the home worker. It deals with the principles of reinforcing, form construction, mixing by hand and machine, foundations, materials and reinforcing, and a great many other specific uses to which concrete can be put. Of concrete books there is no end, but this book would seem to fill a decided want so far as the non-technical concrete worker is concerned. The author has endeavored to translate technical expressions and technical terms into plain, everyday English, so that any one who can read can understand it. The text is accompanied by fifty-one simple drawings, in some cases these drawings being purposely exaggerated to better show what is meant.

Hydraulic Flow Reviewed. By A. A. Barnes, A.C.G.I., Assoc.M.Inst.C.E. Published by E. and F. N. Spon, Limited, London, and Spon and Chamberlain, New York. First edition, 1915. 158 pages, 6 x 9½ ins., with frontipiece and 11 folding plates, cloth. Price, $3.50. (Reviewed by John H. Parkin, B.A.Sc., University of Toronto.)

This book, written by an English engineer, is similar to that of Williams and Hazen, so familiar to hydraulic engineers in America. The general equation employed is of the same form, in the notation of the book $v = K m \propto i B$, but in this equation K, $\propto$ and B are constants for each type of pipe or channel, all three changing with a change in type while being independent of size or proportions.

In the first part of the book, which deals with the flow of water in pipes and channels, is given the method of determining the values of K, $\propto$ and B for each type, by a system of logarithmic plotting of published experimental results for the particular type. A tabulated test is given of equations for velocity, friction head and discharge for seventeen types of channel from cast iron pipe to a canal or river. For purposes of design the deterioration in carrying capacity is taken care of by the addition of a certain percentage to the required discharge.

A most valuable feature of the book is the portion (some fifty pages) in which are tabulated the results of 807 tests on which the equations are based. The data given is very complete, covering published results of tests on various classes of pipes and channels in many parts of the world. In these tables a comparison is shown in each case of the results by the author's equations and the test results, the agreement being very good.

The second part of the book is devoted to the consideration of the measurement of water and equations are evolved of the same general type, giving the velocity and discharge for V notches, weirs and circular orifices. The equations have the advantages that they contain no valuable coefficient and apply without limitation as to head, breadth, angle of notch, etc. The equations are based on published experimental data which is given in tabulated form in the book, together with the results as given by the author's equations showing the close agreement forming a valuable reference feature.

A number of large size logarithmic charts are provided for the solution of problems dealing with cast iron and steel pipes, channels, rivers, weirs and circular orifices.

The book forms a very concise review of the experimental work done on the flow of water and the tabulated data gives it a high place as a reference work. The author's treatment, while leading to equations similar to that of Williams and Hazen, is a step in advance through the elimination of the troublesome Chezy coefficient and the adoption of different values of the exponents for different channel types, which admittedly gives more accurate results than a single pair of exponents for all cases. The work should be of much value to hydraulic and irrigation engineers or those having to do with the flow or measurement of water.

American Civil Engineers' Pocket Book. Edited by Mansfield Merriman and fifteen associate editors. Published by John Wiley & Sons, Inc., New York. Third edition, 1916. 1,571 pages, 4¼ x 7 ins., 1,300 cuts and 550 tables, leather. Price, $5 net.

This is a new edition, being the third since the work was published in 1910. A great many minor changes have been made and some new matter has been added, the following being a short list of the more important: Azimuth of Polaris at Elongation, and other astronomical calculations; Statistics of Railroad Operation; New Specification for Cement Testing; Arches Under Water Pressure; Discharge and Friction Heads for Long Pipes; Biel's Formula for Flow in Pipes and Channels; besides other matter which makes each section more complete. The book now contains 41 articles, 31 tables, 103 cuts and 120 pages more than the second edition.

An entirely new section of 96 pages has been added covering harbor and river works. Frederick R. Harris, Corps of Engineers, U.S. Navy, is responsible for the section.

Wave action, wave protection devices, such as breakwaters, bars, for shore protection and channel regulation are fully taken up. Chapters on quays and landing places are very complete and well illustrated.

The chapter on wet and dry docks is deserving of special mention for its completeness in such small compass. Although this chapter is the largest of the six in the new section, covering as it does 27 pages, there is enough information contained in it to enable an engineer who is at all familiar with dock work, to design and construct almost any form of wet or dry dock. The illustrations are well chosen and easily understood.

Floating and sliding caissons and other special forms of steel constructed caissons for entrance gates are illustrated, but no attempt is made to go into the question of design. Evidently the author considers such work as being out of the scope of a civil engineer's pocket book. The design of floating dry docks is taken up with some detail and some cost data is added.

This pocket book, in its new form with the many minor changes, and additions which make the individual sections more complete, and the addition of the new section on harbor and river works, will undoubtedly find favor with a great many engineers who have not before found such a work to be so complete and covering nearly all their requirements.

The Web of Steel. By Cyrus Townsend Brady and Cyrus Townsend Brady, Jr. Published by Fleming H. Revell Co., New York.

It is seldom that a novel makes a special appeal to the engineering profession. This is the case, however, in "The Web of Steel," just published. It is a good romance, with an engineering flavor, and written by Cyrus Townsend Brady and Cyrus Townsend Brady, Jr. The father has several other novels to his credit and the son is a civil engineer. The preface states that the volume is a book for men, about men, and written by men. It has all the good points of a popular novel, and the writers say that whatever may be said of their fiction, they "rest confident in the engineering." As "no scientific course is necessary for the comprehension of the story," this interesting volume will be read not only by engineers, but also by their ladies. The story is divided into four parts under the following headings: I., Bridge; II., C-10-R; III., Dam; IV., Spillway.

The novel is a well-written narrative, and will hold the reader until the closing page. "The Web of Steel," by C. T. Brady and C. T. Brady, Jr. Published by Fleming H. Revell Company, New York.

Practical Design of Steel-Framed Sheds. By A. S. Spencer. Constable and Co., London, Eng. (Reviewed by A. J. MacDougall, Mechanical Engineer, Toronto Power Co.).

In the first chapters of this book, after analyzing the effect of wind stresses, standard designs of roof trusses for sheds and the stresses in the various members are given. The book is then concluded with descriptions of external coverings and attachments for buildings.

This book is recommended to the engineer who lacks the time to make the calculations and design his own trusses, but is not recommended to those who, lacking knowledge of structural calculations, would place on their structure a ready-made design of truss. The reviewer is of the opinion it will pay in almost all cases to have a competent structural engineer design the structural steel.

Air-Craft in War and Peace. By Wm. A. Robson. Published by Macmillan Company of Canada. Price, 75 cents.

This is a new book, just issued, on this all-absorbing topic, and is written in plain, non-technical language. It points out with wonderful clearness the important part that air-craft has come to play as weapons of war. The author attempts to lay before the general public some of the outstanding points that have been brought to the surface as the result of the use of air-craft in the present war. The book is well illustrated and exceedingly readable, and should be of great interest to those who are at all interested in the subject. It contains 176 5 x 7½-in. pages, bound in cloth, and will, no doubt, form a welcome addition to literature of the science.

Parks and Park Engineering. By Wm. T. Lyle, A.M. Am.Soc.C.E. Published by John Wiley and Sons (Inc.), New York. 129 pages, 38 half-tones, 5½ x 9 ins. Price, $1.25 net. (Reviewed by R. B. Evans, A.M.Can.Soc.C.E., Parks Engineer, City Hall, Toronto.)

In reviewing a work on Parks and Park Engineering one must be broad enough to admit that Engineering is a large subject. The author has compiled an interesting book on this subject, introduces several good points on carrying out grading and drainage, and is not afraid to help the student who wants to know the correct grade for a sewer.

He touches on one or two personalities with whom the ordinary reader might or might not be familiar, and does not go deeply into the important subject of roadways. The work, however, gives some results of the latest practices in road surfacing with oils, etc., suitable for the ever-increasing automobile traffic, and an account of some modern boulevard pavements.

Some ideas re the acquisition of parks would be excellent reading for those interested in the improvement of cities and towns.

The methods of survey are up-to-date and similar to those in use in Canada.

Chapter III., on Design, touches on some large city improvement work, as well as some detail of taking care of parks and roadways.

The importance of getting rid of water as quickly as possible by various methods is emphasized, but none too strongly, as this, to the writer, is one of the most important items in engineering work.

The last chapter, on Construction, shows how one can make a smooth road for others to travel, which is the work of the conscientious engineer, no matter what particular line he may be following.

General Specifications for Concrete Bridges. By Wilbur J. Watson, Mem.Am.Soc.S.E. Third edition. Published by the McGraw-Hill Book Co. (Inc.), New York. 70 pages, 8 x 11 ins., paper. Price, $1.00. (Reviewed by E. M. Proctor, Department of Bridges, City Hall, Toronto.)

These specifications, by the well-known author of "Concrete Specifications," are brought up to date in this, the third edition. The sections on Surface Finishing, Waterproofing and Quality of Materials have been rewritten. It is in these three branches of the subject that the greatest advancement has been made in late years. Many other radical changes have also been made throughout the book.

The general arrangement of the specifications is exceptionally good. There are twenty-seven sections, each section dealing with some distinct branch of concrete bridge building. The sections dealing with design are not as complete and well arranged as those sections dealing with construction. This is evidently the result of the author having viewed his work from the construction engineer's standpoint.

A few points might be mentioned to illustrate the above contention. The loading specifications call for the uniform live load to be 100 lbs. per sq. ft., sidewalk and road, regardless of the length of the bridge. The concentrated loads are, if anything, too heavy. A few diagrams showing wheel-spacing, etc., would have been a great help to the designer. In Section II., "Rules for Computing and Designing," "the length of span for reinforced concrete beams, girders, slabs, etc., computed as simple beams, shall be considered to be the clear distance between supports," is one of the clauses. Very few specifications are as liberal as this. In a general specification like this it would have been better to have given a graded scale of temperature ranges rather than a range for latitude 40° only. In concrete arches the temperature plays a very important part, and has generally a greater range than +35° Fahr., as specified. A clause dealing more fully with this would not be out of place. The specification for bonding of steel rods in concrete are very liberal. Fifty per cent. may be developed by a 90° bend, and deformed rods are allowed to be bonded in one-half the length of plain rods. The results of the recent tests, as published in Bulletin No. 71 of the University of Illinois, no not bear out these specifications.

Sect. IV., "Formulæ," hardly has a place in a specification. These formulæ are given in all test books and are quite standard. Formulæ Nos. 1, 16 and 17 are evidently printed incorrectly.

Sect. V., "Quality of Materials," is the standard requirement of the American Society for Testing Materials.

Sect. VI., "Proportioning, Mixing and Placing Concrete"; Sect. VII., "Placing Reinforcing Steel"; Sect. VIII., "Placing Concrete in Cold Weather"; Sect. IX., "Forms and Centres," are all very well written and arranged, and if followed will produce a high-class product.

Sect. X., "Surface Finish," and Sect. XI., "Waterproofing," are excellent, and cover in six pages the various methods of modern practice in this rapidly developing branch of engineering. Sects. XII. to XXI. treat the following subjects in an able and concise manner: "Reinforced Steel Construction," "Cast Stone and Blocks," "Concrete Piling," "Inspection and Tests," "Retaining Walls, Abutments, Piers, etc.", "Concrete Arches," "Reinforced Concrete Slabs, Beams, Girders, Columns and Trusses," "Foundations and Footings," "Timber Piling," "General."

The last six sections are a valuable addition to bridge specifications; they deal with the pavement on the bridge. The titles of the sections are. "Cement Walks, Concrete Curbs and Roadways," "Brick Pavement," "Asphalt Block Pavement," "Sheet Asphalt Pavement," "Wood Block Pavement," "Bituminous Pavement."

Taking the specification as a whole, there are few, if any, concrete bridge specifications that cover so much ground and yet are so concise and well arranged. No engineer will make a mistake in adopting these specifications.

Proceedings of the Pan-American Road Congress, held at Oakland, California, September 13, 14, 15, 16 and 17, 1915. (Reviewed by S. G. Talman, A.M.Can. Soc.C.E., Roadways Department, City of Toronto.)

This comprehensive collection of papers will prove a very valuable addition to the library of the highway engineer, and is instructive reading for the layman road user interested in good results and how to get them. To cite one example from the many, the paper, "Highway Indebtedness; Its Limitation and Regulation," deals with facts with which every taxpayer should make himself familiar. Besides the purely technical, the papers treat the subject from every possible viewpoint, such as historical, financial, legal, etc. American thoroughness marks the proceedings from beginning to end.

PUBLICATIONS RECEIVED.

Economic Methods of Utilizing Western Lignites.—Bulletin No. 89 of the United States Bureau of Mines.

The Canadian Railway Club.—Official proceedings, April, 1916. This issue contains a paper by S. J. Sargant on "The Railways of India."

The Resources of Tennessee, No. 2, Vol. 6.—A magazine devoted to the description, conservation and development of the resources of the State of Tennessee. This number contains articles on phosphates of Johnson County, Tennessee, and notes on manganese in East Tennessee.

A Matter of Opinion.—Issued by the Canadian Forestry Association, Booth Building, Ottawa. The pamphlet is from the pen of Robson Black, the secretary of the Association, and is designed as a warning with the object of preventing, as far as possible, the firing of our forests.

Reports, St. John, N.B.—A 400-page booklet containing the reports and accounts of the city of St. John for the year 1915. Includes reports by William Murdoch, city engineer; F. L. Potts, works commissioner; A. Winchester, superintendent of streets; and G. N. Hatfield, road engineer.

Patent Protection.—Issued by Babcock & Sons, patent attorneys, Montreal. Gratuitous distribution. Deals with protection of inventions in Canada, United States and abroad. Well indexed. Covers costs, patentability of inventions, time required to obtain patent, and many similar matters.

Regulations Respecting Highways, 1916.—Issued by the Department of Public Highways, Ontario. It contains the regulations of the Department of Public Highways with respect to county road construction, maintenance and repair under the Highway Improvement Act and the Ontario Highways Act.

Reasonable Regulation of Railroads.—A report submitted to the Joint Committee on the reasonable regulation of railroads, which committee was formed in March, 1915, by representatives of ten of the leading commercial organizations of Philadelphia. Copies of the pamphlet can be secured by addressing Mr. Emil P. Albrecht, 214 The Bourse, Philadelphia, Pa.

Standard Specification for Cast Iron Water Pipe and Special Castings. Issued by the Canadian Society of Civil Engineers. These specifications, which were approved for re-printing by the Annual Meeting of the Society held in January last, have now been issued. Contains thirty-four

6-in. x 9-in. pages. They will be found of peculiar interest to all those who have to do with the design, construction and maintenance of all kinds of waterworks, sewage, filtration and industrial plants.

Russian Trade Preliminary Report.—This is a reprint of articles dealing with Russian trade by Mr. C. F. Just, Canadian Special Trade Commissioner, and is issued as a supplement to the Weekly Bulletin of the Department of Trade and Commerce. The pamphlet contains a large amount of very valuable information that must be of considerable interest to those whose attention is being turned to Russian trade at this time. It contains 100 6½ x 9½-inch pages.

Steamboat Inspection Report.—This is a supplement to the 48th annual report of the Department of Marine and Fisheries for the fiscal year 1914-15. It contains the report of the chairman of the Board of Steamboat Inspection, list of steamboat inspectors and an alphabetical arrangement of all the steamers, machinery and hulls inspected in Canada during the fiscal year ended March 31st, 1915, and various other tables of peculiar interest to those who have to do with marine matters. It contains 160 6 x 9 pages.

Modern Development in the Sugar Industry.—An interesting brochure sent out by the J. G. White Companies of New York, devoted to an interesting description of the development of the sugar industry. Reference is made to the constantly increasing amount of capital that is coming to be invested in the sugar industry and to the announcement of the establishment of a sugar engineering department under the auspices of the White Companies, this department being designed to cover all the activities of the sugar industry.

Fourth Annual Report of the Manitoba Public Utilities Commission.—This report covers the period for the year ended November 30th, 1915. It contains 138 pages and a special feature of it is the very exhaustive report of Albert F. Ganz, consulting engineer, on what he found in his investigations for stray electric currents in the city of Winnipeg and adjoining municipalities. The report also deals with the Winnipeg River Power Company, the Utilization of Domestic Coal, the Natural Resources of the Province, the Annual Report of the Manitoba Government Telephones. The report will be found of great interest to many who are concerned with the administration of public affairs in general.

Rules for Conducting Performance Tests of Power Plant Apparatus.—This is a report of the power test committee appointed by the American Society of Mechanical Engineers in April, 1909, to revise the present testing code of the Society relating to boilers, pumping engines, locomotives, steam engines in general, internal combustion engines, and apparatus and fuels therefor, and to extend these codes so as to apply to such power-generating apparatus as the present codes do not cover, including water power, bringing them into harmony with each other and with the best practice of the day. This report, which contains 218 pages, will be found of considerable interest to many of our readers, especially those of them who are connected with hydro-electric practice. It contains rules for conducting tests of all classes of power apparatus. The committee has gone into this matter very thoroughly, indeed, and practically almost every point is touched. Those who are interested will probably be able to secure a copy of the report by addressing Calvin W. Rice, Secretary of the American Society of Mechanical engineers, New York.

COAST TO COAST

Montreal, Que.—More than two thousand guests witnessed the launching of the "J. D. Hazen," the second largest ice-breaker in the world, from the shipbuilding yards of the Canadian Vickers, Limited, at Montreal, May 15th.

Peterborough, Ont.—The Appellate division has dismissed the appeal of the city of Peterborough from the decision of Justice Britton upholding the award of the arbitrators who fixed $154,615 as the amount to be paid by the city for the plant of the Peterborough Light and Power Company, Limited, which the city took over. The application by the city to examine the arbitrators as to their award is also dismissed.

Vancouver, B.C.—Arrangements for continuing the geodetic survey of the British Columbia coast, started last year, are being made by Mr. Noel J. Ogilvie, assistant superintendent of the Dominion Geodetic Survey Department, who is in charge of the extensive operations on the Pacific seaboard. Two small parties in charge of Mr. W. H. MacTavish, an engineer of the department, left for Prince Rupert recently to commence observations off Dixon Entrance.

The Pas, Man.—The Ottawa government will not undertake the expense of surveying the boundary line between Manitoba and Saskatchewan, north of 60, to determine the location of Flin-Flon and Athapapuskow Lakes. This information was contained in a letter to the Board of Trade from J. H. Challoner, head of the survey branch of the Department of the Interior. The status of the sulphide ore lakes will remain unknown until the survey is made.

Montreal, Que.—On the mezzanine or sacking floor of the $800,000 addition to Elevator No. 1, Lady Borden recently gave the signal which started the machinery in motion for the first time and opened the bin valve to allow a continuous stream of wheat to fall out on the ever-moving belt beneath. In so doing she inaugurated the active life of what is now the largest seaport elevator in the world, the new addition giving elevator No. 1 a total capacity of 4,000,000 bushels.

Montreal, Que.—Gigantic steam shovels weighing 65 tons each, capable of eating up the earth at the rate of 150 to 200 cubic yards an hour, and self-propelling extension track pile drivers, are part of the equipment recently purchased by the government for Col. C. W. P. Ramsay, of the Canadian Overseas Railway Construction Corps. This plant was selected by Col. Ramsay's colleagues in the engineering department of the Canadian Pacific Railway and is being prepared by that company at the request of the government for shipment abroad.

Fort William, Ont.—The city of Fort William still does not desire the Canadian Car and Foundry Company to sell its Fort William plant to the Russian government. The company some years ago received certain concessions for building the establishment there, but the plant, although completed, has not operated yet. The city recently had a visit from Mr. W. W. Butler, vice-president, and Mr. K. W. Blackwell, one of the directors of the company, who met the council and discussed with them the question of the removal of the car plant from Fort William. The council met last month and the case on behalf of the car company was presented. After full discussion a motion was adopted that council was not favorable to the removal of the car plant.

Editorial

ACTIVATED SLUDGE.

It is questionable whether the optimist could have predicted the great developments which have been and are taking place in connection with the activated sludge process. Prof. Gilbert J. Fowler announced in 1913 the results of experiments made at the Manchester sewage works by adding iron salts, inoculation of sewage with an organism and blowing in air, which produced a "limpid, sparkling and non-putrefactive effluent." This research was undertaken because of a suggestion made to him by Dr. Maclean Wilson that it might be possible to "discover some kind of clotting enzyme which should do the work which now apparently takes place on the surfaces of the medium of the filter bed." Dr. Fowler, when reading a paper before the Liverpool Engineering Society on March 4th, 1914, stated that he looked "forward with confidence to the time when it will be possible completely to purify sewage in a tank with the production on the one hand of inoffensive sludge which can be readily handled and disposed of as manure, and on the other of a well-aerated effluent."

In May, 1914, the world learned of the results obtained by Messrs. Ardern and Lockett, who were collaborating with Dr. Fowler and from that time to the present sanitarians have in many lands given the activated sludge process a great amount of consideration. Those who have kept in touch with the progress of sewage treatment during the past generation can recall the multitude of methods which were tried; but the standards of purification and the efficacy of the processes did not work out in practice according to the predictions of those who heralded their inception. Consequently, we have been waiting and observing, delving into Nature's mysteries and slowly bringing to light many valuable discoveries which in the aggregate have brought the science and art of sewage treatment within a measurable distance of the desired goal.

We have before us the report issued by the Milwaukee Sewerage Commission, the bulk of which deals with extensive experimentation in connection with the activated sludge process. The forward step taken by Mr. Chalkley Hatton, the chief engineer, and his chief chemist, Mr. William R. Copeland, in advising the Commission to construct a two-million-gallon-per-day plant, commands admiration, for no doubt many problems and difficulties are brought out, when operations are conducted on a large scale, which are often unobserved in the laboratory. Milwaukee experiments have revealed some of these. For example, the diffusion of air has, in practice, apparently not proved so easy of attainment as was originally anticipated. Mr. George W. Fuller has drawn attention to several points which deserve consideration, and no doubt with patient research they will be satisfactorily solved.

The process, nevertheless, is advanced sufficiently to indicate that it is applicable under a great variety of conditions. It will treat sewage containing large proportions of trade wastes which have hitherto caused great trouble, and also sewage which is entirely domestic; but in each case the treatment, although identical in principle, must be varied according to the strength and characteristics of the sewage. The effluents obtained by the process exceed in superiority those got by ordinary methods, even with ample area of filters and efficient sterilization. Furthermore, it was possible at Milwaukee to purify about 10 million U.S. gallons per acre, whereas only 2.5 millions are possible by the older methods.

The ordinary haphazard attention, however, will spell failure because, on the one hand, there must not be an accumulation of unoxidized sludge, nor, on the other, much exhausted sludge due to over-aeration. There is a great measure of flexibility in the process, for by aerating the sludge during the period of minimum flow and weak sewage it is possible to charge the incoming sewage during the other periods with vigorous activated sludge.

Whilst the effluent from these tanks is clarified and purified to a greater degree than is possible by ordinary sewage treatment, the sludge which has always been the great bugbear of sewage works is made valuable as a fertilizer, owing to the proportion of nitrogen, phosphorus and potash contained therein. Activated sludge drains easily and can be pressed into cakes. The use of lime, however, may probably be avoided by using fine ashes, coal or lignite dust, or dry peat, and it would be instructive if experiments were made on these lines. Screened cinders are found effective with ordinary sludge at Oldham, and Degeur used lignite in Germany. As activated sludge contains about 98 per cent. of water it will be seen that if the moisture content was reduced to 20 per cent. the weight would be reduced from 100 to 2.5, which is a most important factor in its manipulation.

Although Canadian municipal authorities will learn much by the work done by British and American experiments, there is more to be gained by carrying on similar work because there is a great deal of knowledge to be acquired by observing the particular features of the process under different conditions. No scientist can express in language all the knowledge he has gained, even if he should write volumes. It is the personal contact with a new process which reveals its full value.

The comprehensive experiments made at Milwaukee have so fully confirmed the statements made by Messrs. Ardern and Lockett that there remains but little doubt in the minds of sanitarians generally, that we are to witness a great revolution in the method of sewage treatment and the standards of purification which will in future be attainable in ordinary everyday practice.

AN INTERESTING ANNOUNCEMENT.

As indicating the confidence of the French people it is interesting to note that plans are now being formulated for the holding of a Reconstruction Exposition in Paris during May, June and July of this year. In a statement to manufacturers it is pointed out that the war has laid bare the habitations of 35,000,000 people and destroyed county roads, city streets, public service systems, factories and farms. This, indeed, is a most interesting announcement and indicates the spirit of the people. It spells hopefulness at least. The prospectus adds that the end of the war will mark the beginning of the work of reconstruction and for this a vast amount of machinery and supplies will be necessary.

PERSONAL.

H. D. CAMERON has been appointed mechanical engineer of the Canadian Northern Railway, with office at Toronto, Ont.

Prof. WM. NICOL, of Queen's University, has resigned after having been professor of mineralogy for twenty-five years.

C. A. COTTERELL has been appointed superintendent, district of Alberta division, Canadian Pacific Railway, with headquarters at Lethbridge.

J. E. B. PHELPS, former chief engineer of the Sarnia Electric Light Company, has been appointed general manager of the Sarnia (Ont.) Hydro Power Commission.

Sir ADAM BECK, chairman of the Hydro-Electric Power Commission of Ontario, has had the degree of LL.D. conferred upon him by Western University, London, Ont.

J. G. SULLIVAN, M.Can.Soc.C.E., chief engineer of the western lines, Canadian Pacific Railway, has been elected first vice-president of the American Railway Engineering Association for 1916-1917.

ALLAN PURVIS, superintendent of the C.P.R. at London, Ont., has been appointed general superintendent of the Eastern Division in place of A. E. Stevens, who has been transferred to a similar position at Moose Jaw, replacing J. G. Taylor, who had to relinquish his duties on account of ill-health.

W. GRANT FRASER, of New Glasgow, N.S., has been appointed under the Imperial Munitions Board, as chief inspector of all munition factories in the Maritime Provinces. Mr. Fraser has had a long experience in steel manufacture, having been one of the smelter foremen for the Nova Scotia Steel and Coal Co., both at New Glasgow and at Sydney Mines.

A. F. MACALLUM, C.E., M.Can.Soc.C.E., city engineer of Hamilton, Ont., has resigned to accept the position of works commissioner of Ottawa, Ont. Mr. Macallum was chosen unanimously by the Ottawa Board of Control at a meeting last Thursday morning, and his appointment was ratified by the city council at a special meeting held that evening. Mr. Macallum is president of the American Society of Municipal Improvements, and is one of the best-known municipal engineers in Canada. He is a graduate of the School of Practical Science, University of Toronto, and is a member of the American Society of Civil Engineers. For several years after graduation Mr. Macallum was engaged in railroad work. He was then appointed assistant city engineer of Toronto, and later entered private practice at Toronto. He has been city engineer of Hamilton for seven years. Mr. Macallum is an able and popular engineer, and carries with him to his new position the good wishes of all of his fellow Canadian engineers.

ANNUAL CONVENTION OF THE ROYAL ARCHITECTURAL INSTITUTE OF CANADA.

The General Annual Assembly of the Royal Architectural Institute of Canada will be held at Quebec, Que., on Saturday, 9th September, 1916. All Canadian architects are invited and a record attendance is expected. J. H. G. Russell, Winnipeg, Man., President. Alcide Chaussé, 5 Beaver Hall Square, Montreal, Que., Hon. Secretary.

MANITOBA BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

The regular monthly meeting of the Electrical Section was held May 10th, when F. H. Martin gave a talk on "Water Wheels."

EDMONTON BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Edmonton Branch of the Canadian Society of Civil Engineers held their special meeting for the election of officers for the ensuing year on the 10th instant at the Cecil Hotel. About twenty members of the Society, resident in Edmonton were present.

After a pleasant and informal dinner, the business of the evening was taken up. The following officers were elected to be installed next October when the new season commences: Chairman, L. B. Elliot; vice-chairman, J. Chalmers; secretary-treasurer, C. A. Robb; executive committee, A. T. Fraser, D. J. Carter, J. L. Coté, D. Donaldson. After other regular business brought before the branch was disposed of, the meeting adjourned at 9.30.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The nineteenth annual meeting of the American Society for Testing Materials will be held at Atlantic City, N.J., June 27 to 30. Headquarters for the meeting will be at the Hotel Traymore. A summarized programme of the meeting follows:—

First session, Tuesday, June 27, 11 a.m.—Minutes of eighteenth annual meeting; report of executive committee; various committee reports; announcement of election of officers; miscellaneous business.

Second session, Tuesday, 3 p.m.—Reports of committees on miscellaneous materials.

Third session, Tuesday, 8 p.m.—Presidential address and reports on heat treatment of steel.

Fourth session, Wednesday, 10 a.m.—Reports on steel and iron. Wednesday afternoon will be reserved for recreation.

Fifth session, Wednesday, 8 p.m.—Reports on tests and testing.

Sixth session, Thursday, 10 a.m.—Reports on cement and concrete.

Seventh session, Thursday, 3 p.m.—Reports on ceramics and road materials. Thursday evening will be reserved for a smoker.

Eighth session, Friday, 10 a.m.—Reports on nonferrous metals and cast iron.

Ninth session, Friday, 3 p.m.—Reports on miscellaneous materials.

In connection with the forthcoming Convention of the American Water Works Association to be held in New York, June 5-9, it is proposed to take delegates, who so desire, to see either Kensico Dam and reservoir, in which is stored 38,000,000,000 gallons of Catskill Mountain water, the Ashokan Aerator at the beginning of the Catskill Aqueduct, or the new four truck double deck subway in rock tunnel in Lexington Avenue, New York City. No doubt many of the delegates will be glad to take full advantage of seeing these important engineering works.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

THE NEW QUEBEC BRIDGE

AN INTERESTING ACCOUNT OF THE METHOD TO BE EMPLOYED IN HOISTING THE SUSPENDED SPAN INTO PLACE — THE WEIGHT OF THE SPAN IS APPROXIMATELY FIVE THOUSAND TONS.

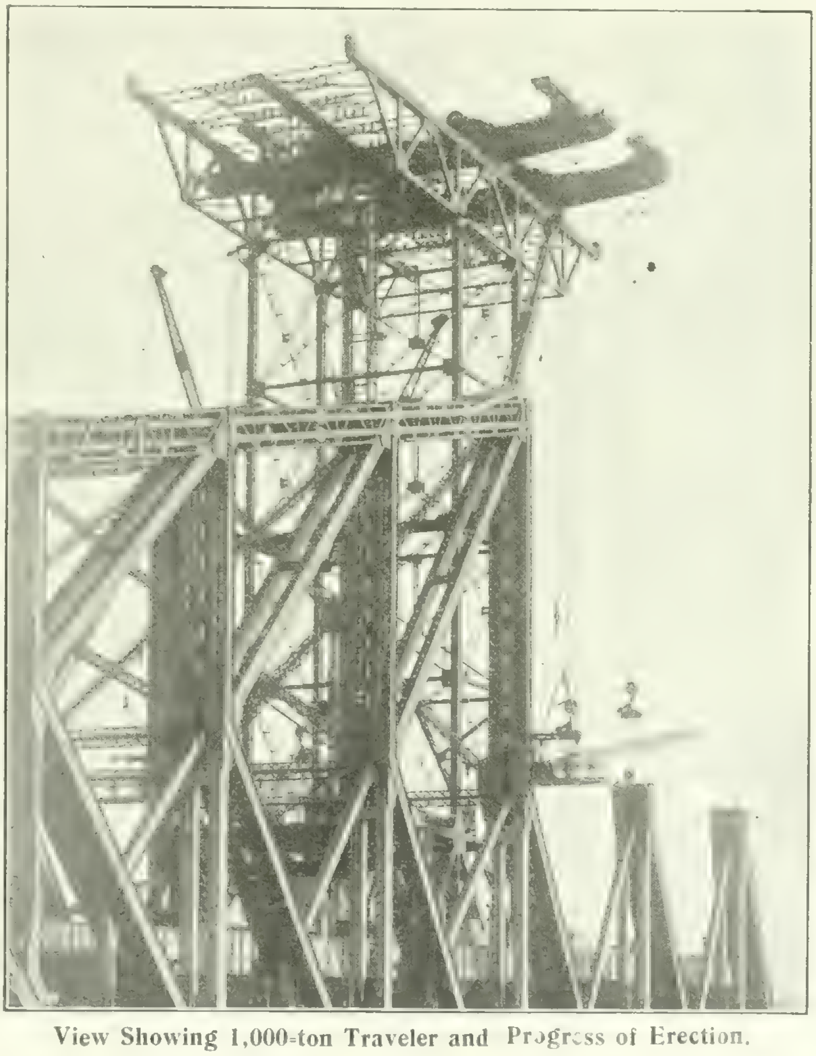
By A. J. MEYERS,
Chief Draftsman, Board of Engineers, Quebec Bridge.

THE contract for the construction of the piers for the Quebec Bridge was awarded to M. P. and J. T. Davis, of Quebec, in February, 1910. This phase of the work was very fully described in the issue of July 9th, 1914, in an article by Mr. H. P. Borden. The close of the year 1914 found considerable progress had been made.

During the season of 1915 most satisfactory progress was made, a detailed account of which was published in *The Canadian Engineer* September 23rd, 1915.

On July 8th, 1915, the erection of the main shoe on the south shore started. Work in connection with this part of the construction was greatly facilitated by the experience gained.

On November 12th, 1915, when the erection programme for the new Quebec Bridge was finished for the season, the north shore anchor and cantilever arms and the south shore anchor arm including the main post, had been completed. The total tonnage erected up to that time amounted to approximately 46,000 tons, about 30,000 tons of which had been placed during the 1915 working season of seven months, from the middle of April to the middle of November. The total quantity of steel in the bridge will weigh in the neighborhood of 65,000 tons, so that the programme for the season of 1916 calls for the erection of about 19,000 tons, a comparatively easy task, judging from the records of the past summer. Of this 19,000 tons, the south shore cantilever arm contributes 13,000 tons and the suspended span 6,000 tons.



View Showing 1,000-ton Traveler and Progress of Erection.

Work on the erection of the south shore cantilever arm was properly started about the middle of April, 1916, and at the time of writing this article, the first panel and a half, adjacent to the main pier, is practically completed. It is expected that the progress of erection of the south shore cantilever arm will be approximately as stated in the schedule on the following page.

The method of erection of the south cantilever arm is entirely the same as that followed on the north cantilever arm, and, as noted above, it is expected that this work will be finished by the end of the first week in September, 1916, when the bridge will be in readiness for the floating in and hoisting into place of the suspended span.

The suspended span is a double-track, curved top chord span, 640 feet long, 110 feet high and 88 feet wide, and weighs in the floating in condition approximately 5,000 tons. The greater part of the floor steel, being left off while the span is being floated and hoisted into place, will be placed by

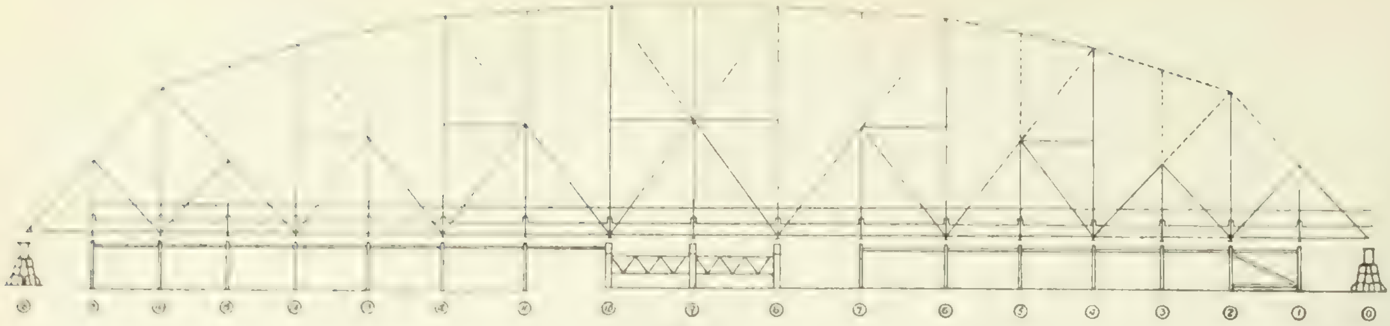


Fig. 1.

means of a derrick car after the span has been coupled up to the ends of the cantilever arms.

Schedule Showing Approximate Progress Expected in Erection of South Shore Cantilever Arm.

Main panel.	Days required.	Date of completion	Tons of steel to be erected.
16-14	40	May 10th	3,100
14-12	30	June 9th	2,650
12-10	22	July 1st	[illegible]
10-8	16	July 17th	1,460
8-6	12	July 29th	1,300
6-4	9	August 7th	850
4-2	14	August 21st	[illegible]
2-0	15	September 5th	[illegible]
Total....	158		12,000

This span will be erected in the shallow waters of Victoria Cove, on the north shore of the river, about three miles below the bridge site, the work of erection proceeding simultaneously with that of the south shore cantilever arm.

The foundations for the falsework bents supporting the trusses and approach track were prepared during the season of 1915 at the periods of low tide. This work was rather difficult, considerable blasting having to be done, and could not be carried on with any very great speed as the time available was only from two to four hours each day.

As shown in the accompanying Figs. 1 and 2, the span will be supported during erection on staging bents placed under each panel point. The traveler, which is the same one that erected the north shore cantilever and anchor arms, but with the top trusses and travelling cranes left off, will be first erected on bents 19 and 20, immediately adjacent to the staging of the span. The steel will be handled by means of four 70-foot 30-ton booms, placed one at each of the four corners.

With the traveler at bent 19, the staging bents 0, 1 and 2, the longitudinal bracing between bents 1 and 2, and the bridge material in panel 0-1 will be placed. The traveler will then move forward, erecting staging and

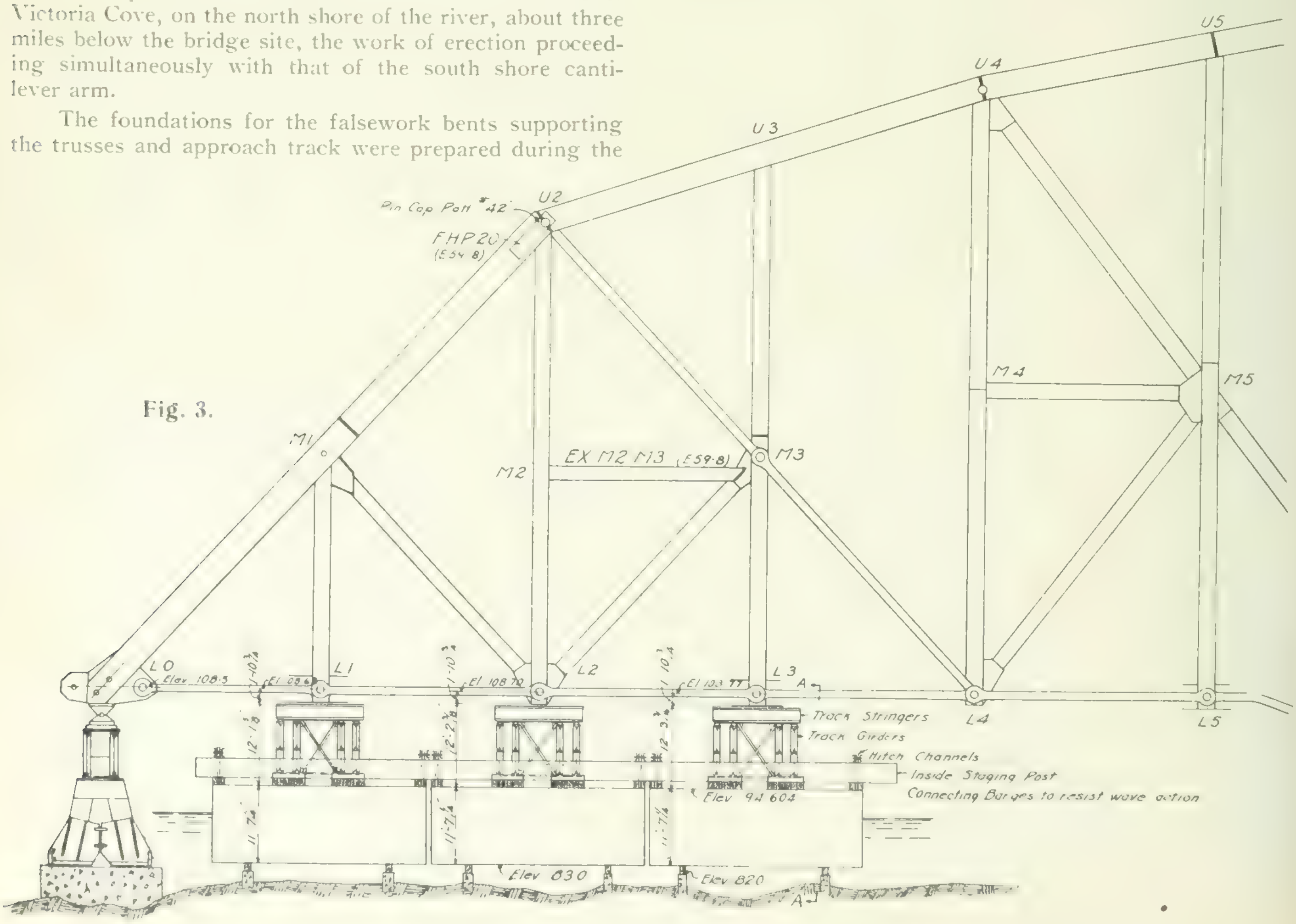


Fig. 3.

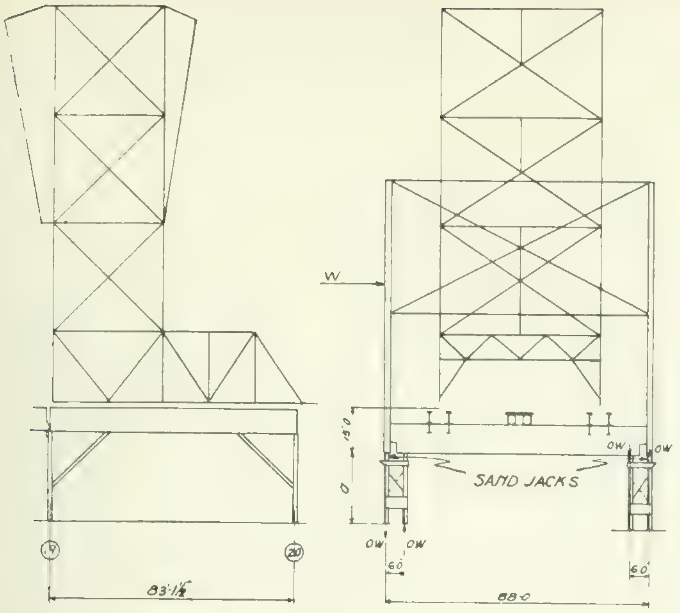


Fig. 2.

longitudinal bracing, floorbeams, bottom chords, bottom laterals and web members, except the upper half of the main diagonals and vertical sub-posts, as it advances until it reaches bent 17. It will then move backwards, completing the erection of the truss members, top laterals and sway bracing.

In Fig. 1 the members erected as the traveler advances are shown in full lines, the members placed on the return trip are shown by dotted lines.

Sand jacks will be used at the even panel points, directly under and with top bolted to the vertical posts, to transfer the load to the outer columns of the staging. Timber blocking will be used for the same purpose at the sub-panel points and also between the floorbeams and inside columns of the staging at all panel points.

The span being completely erected, the timber blocking at the intermediate staging supports will be removed, the sand jacks lowered, and the span will rest on the end bents at L_0 and L_{18}. In this condition, as shown in Figs. 3 and 4, six scows 32 feet wide, 160 feet long, and 11 feet 7 inches draft, will be floated in and placed under the panel points L_1, L_2, L_3, L_{15}, L_{16} and L_{17}. The valves in the bottom of the scows will be opened and the scows sunk until they rest on their foundation supports. The cross-girders and bracing which transfer the loads to the scows will then be placed.

To raise the span from the end supports at L_0 and L_{18}, preparatory to floating out, the scows will be drained at low tide, the bottom valves closed, and as the tide rises the span will be gradually lifted and be in readiness for proceeding on its journey to the bridge site, if the weather and tide conditions are considered favorable. If conditions are not considered favorable, arrangements will be made by means of timber crib guides, tackle running to anchorages on the shore and tugs, so that the span can be returned to its supports.

While the span is on its way to the bridge site, it will be kept under control by means of tugs of sufficient power capacity to overcome all anticipated resistances due to wind and current.

Arriving at the bridge site, the span will be anchored to the ends of the hanging trusses shown in Fig. 5, coupled up to the hanger slabs provided at each of the four corners of the cantilever arms, and raised into its final position by means of the movable jacking girders and eight 1,000-ton hydraulic jacks, two at each corner, as shown on Fig. 3.

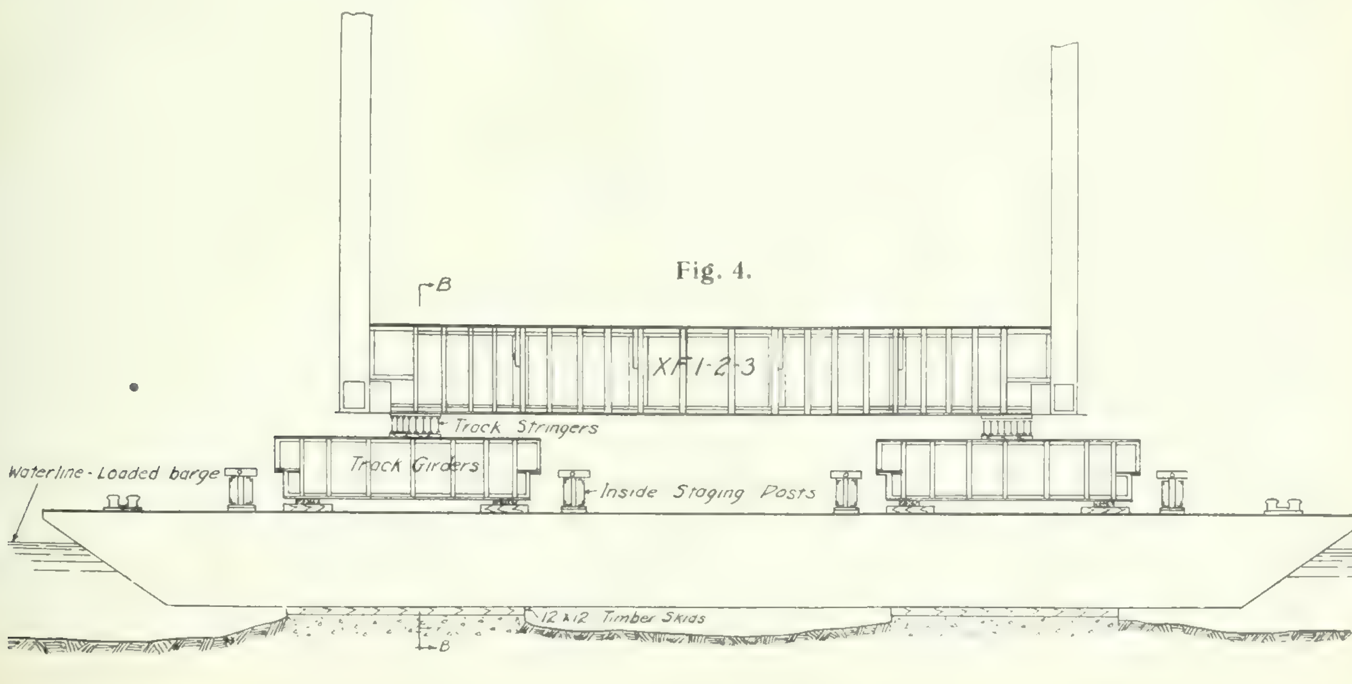
It is expected that this span will be floated into place sometime during September or October, 1916. If this programme is carried out, it will be possible to run trains over this great steel bridge, the largest in the world, and the last link in the National Transcontinental Railway system between the Atlantic and the Pacific, before the close of the year 1916.

The work is being executed under the supervision of the Board of Engineers, Quebec Bridge, composed of C. N. Monsarrat (chairman and chief engineer), Ralph Modjeski and H. P. Borden.

The St. Lawrence Bridge Company are the contractors for the superstructure, George F. Porter being engineer of construction, W. B. Fortune, superintendent, and S. P. Mitchell, consulting engineer of erection.

NOTE:—The construction of the new Quebec Bridge is replete with unique engineering methods and has been

Fig. 4.



closely followed since its beginning in the columns of *The Canadian Engineer*. Interest in this work is practically world-wide and engineers in all countries will rejoice in its successful completion. In the foregoing article Mr. Meyers gives a review of what has already been accom-

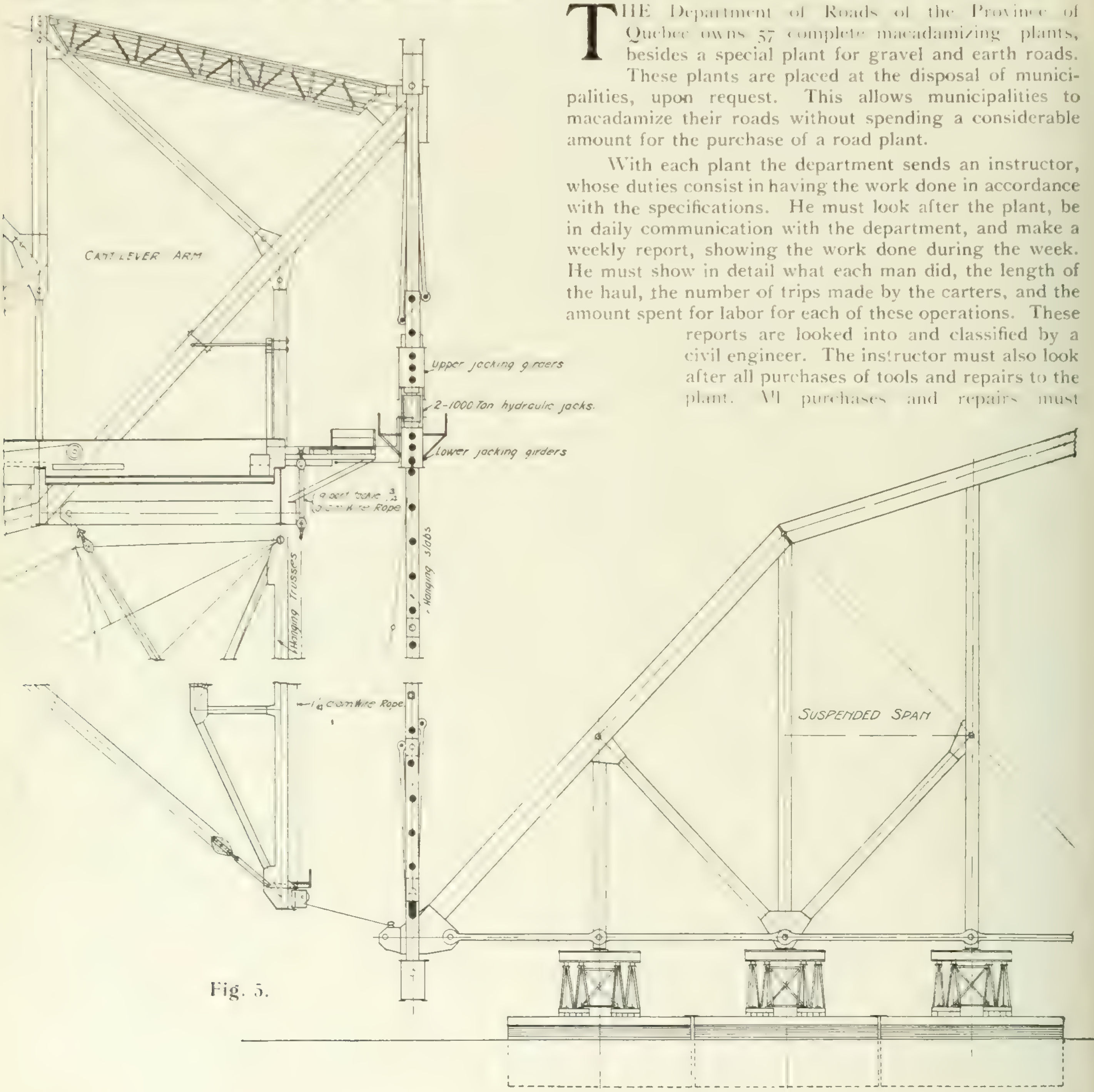


Fig. 5.

plished and gives some interesting information as to the methods to be employed in placing the suspended span. For further details of the substructure and superstructure of the enterprise, readers are referred to the following issues of *The Canadian Engineer*: July 14 and October 6, 1910; June 13, 1911; October 31, 1912; February 13, 1913; April 9, 1914; November 12, 1914; December 31, 1914, and September 27, 1915. [EDITOR.]

The London United Tramways Company, of London, England, last year carried 63,145,000 passengers, or 1,701,000 more than in the previous year.

PRACTICAL MAINTENANCE OF ROAD PLANTS.*

By M. E. Fafard,

Supt. of Road Plants and Construction, Province of Quebec.

THE Department of Roads of the Province of Quebec owns 57 complete macadamizing plants, besides a special plant for gravel and earth roads. These plants are placed at the disposal of municipalities, upon request. This allows municipalities to macadamize their roads without spending a considerable amount for the purchase of a road plant.

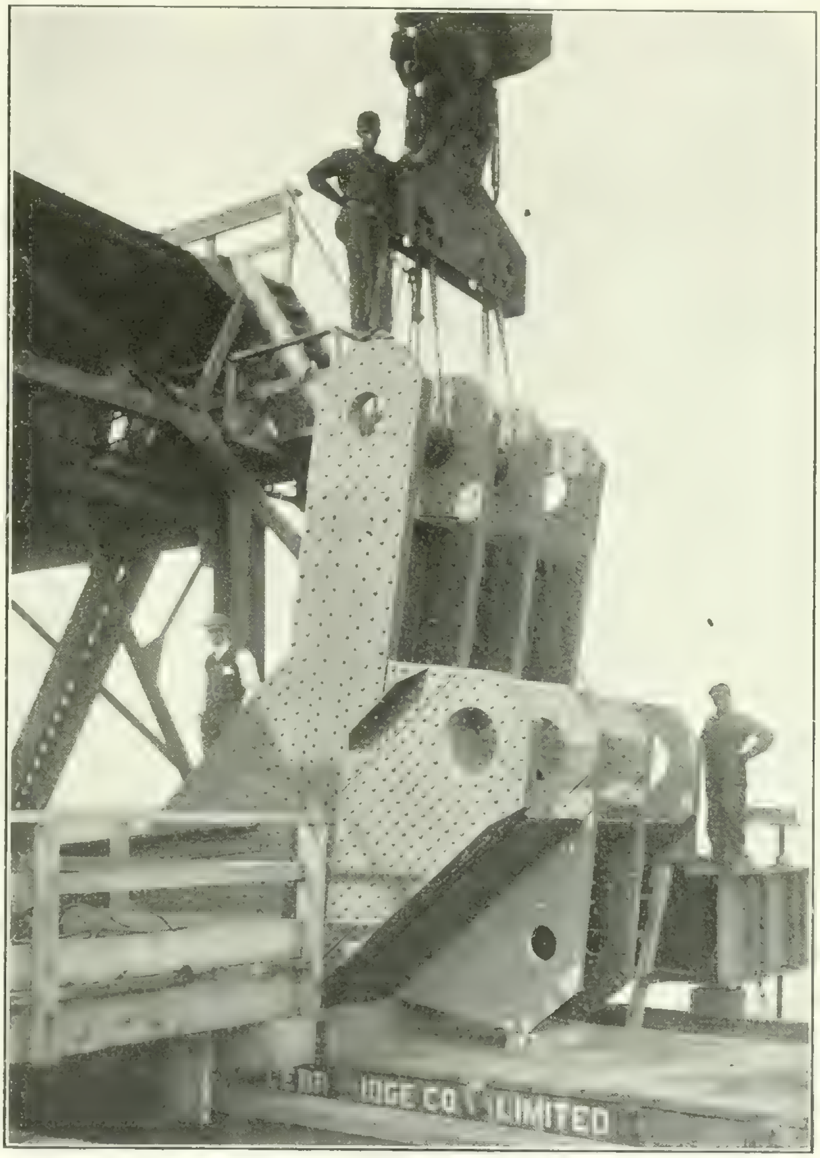
With each plant the department sends an instructor, whose duties consist in having the work done in accordance with the specifications. He must look after the plant, be in daily communication with the department, and make a weekly report, showing the work done during the week. He must show in detail what each man did, the length of the haul, the number of trips made by the carters, and the amount spent for labor for each of these operations. These reports are looked into and classified by a civil engineer. The instructor must also look after all purchases of tools and repairs to the plant. All purchases and repairs must be requisitioned on special blanks signed by him, which are given to the merchants or to those making repairs. Such requisitions must correspond with the accounts that are sent each month to the department to be audited; otherwise the accounts are refused. The instructor must also keep the department posted regarding the state of the plant and of the repairs made or to be made. The advantage given to the municipality of either renting or borrowing the government plant obliges the department

*Abstract of paper read at Third Canadian and International Good Roads Congress, Montreal.

to move many plants from one municipality to another every year.

Repairs and Maintenance.—The method followed at present has been studied and modified, and gives entire satisfaction. We have a head machine repairer, who formerly built plants and road machines, and he has with him another machine repairer of experience. They each have a tool-box containing all the necessary tools to make the repairs on the spot. They also each have a portable smith's forge, because in most cases the plants are far from villages and workshops. They also have the necessary utensils for melting metals, and casting babbitt bearings.

The large parts, which can not be repaired on the spot, are sent to the department's store of spare parts, which attends to the repairs to be made. The repairers work all the season repairing road plants, following instructions of the department. They must go only where the department orders them to go; they must report daily; every Saturday, they must, on a special form, report to the department for each day of the week, use of their time, the places where they worked, the work done each day in each place, the distance covered daily, and whether on a railroad or in a wagon; they must inform the department, by telephone, on Wednesday of each week, of the place where they are, what they have done, and what remains to be done to the plant; they must telephone to the department as soon as repairs are finished, so that they may receive instructions to go elsewhere.



Connection at Panel Point A L2—Bottom Chord, South Anchor Arm, Quebec Bridge.

—See article "The New Quebec Bridge," page 583.

At the beginning of the season before work is started, and in the fall after work is stopped, they are accompanied by four men who have experience in repairing. They are given an itinerary to repair the plants which have suffered the most damage, and to put them in good working order, because, each in their turn, all these plants have to be examined and overhauled. In the fall the head machine repairer inspects the plants which he did not see during the summer, and reports to the department the parts which will have to be repaired during the winter, and he ships to the department's store of spare parts in Quebec, all the parts which will have to be repaired. A linen tag is attached to each part, and the number of the plant from which it comes is written in ink, as well as the name of the municipality. These tags remain attached, so far as possible, to the parts while they are being repaired; thus, there is no confusion in returning the parts.

At the end of the season, the instructor must make a complete inventory, on a special form, of the machinery and spare parts which he has on hand. Moreover, he must explain in detail, for each machine, the repairs necessary. So, should the head machine repairer be unable to inspect all the machines, or should the plant be too far away, the department still knows what repairs have to be made to each machine and to each plant. The spare parts which can be repaired are sent to the store. Before they arrive a new part is shipped to the plant, and the department only charges the municipality with the cost of repairs. This is very economical and also often prevents work being stopped in the busy season. To obtain this result, we require the instructor to telephone to the department every time the plant is out of order to such an extent that he cannot repair it. It is his duty to find out, before telephoning, the exact number of the part. If it has no number, he must be able to describe it accurately, giving its size, etc., so that we can send the right part. If he is unable to give the necessary information, he has to pay for the telephone or the telegram, and is likely to be dismissed, as this would denote carelessness or incompetence.

Our store of spare parts carries a stock of the parts most in use, as we now know the parts which wear out quickest or are likely to break often. Jaws, metals, packings, fittings, oil, etc., are specially chosen. The store has over $20,000 worth of stock. Three employees receive and ship goods. By systematized accounts each part, whether sent from the store, from the shop or by a manufacturer, is charged to the plant which has asked for that part. A record is kept of everything coming in to the store, and nothing is delivered unless requisitioned by the office on a special form.

Shipping of Plants on Cars.—I will briefly explain the orders given to our instructors when it is necessary to ship a plant on cars. The first thing to do is to order the cars in advance, generally three flat cars. While waiting for the cars, all the machines, spare parts, etc., are taken to the station. When the time has come to load the machinery, the wheels of each car must be blocked very carefully, after which a strong platform is built long enough to facilitate the loading of the heavy machines. Too much care cannot be taken in the construction of this platform, which will have to carry loads varying from 6,000 to 25,000 lbs.

Excepting the roller, which goes onto the platform under its own power, the machinery is hauled onto the car by means of a tackle solidly attached to the car and to the machinery, the cable being drawn by horses. While loading the machinery, two men must follow the hind wheels of each machine with good blocks which they slide behind the wheels all the time that the machinery is going up the platform. This precaution has certainly avoided serious accidents, both to men and to machinery. If the cable should break when a machine weighing 6,000 or 8,000 lbs. is at the top of the inclined platform, what would happen if we did not take the necessary means to prevent its coming down?

When all the parts are loaded, every wheel of all machines must be blocked. The best way is to place good blocks, solidly nailed on the floor of the car, in front, behind and on each side of the wheels; special care must be taken in regard to the bin, on account of its great height and the excess of weight at top.

The same instructions apply to the unloading of the machinery.

Installation.—First look over the ground where the plant is to be placed, choose the driest spot, and see to it that water is abundant and not too far away. Do not place the crusher too far from the stone piles, but quite a distance from buildings in order to prevent danger from fire and the inconvenience from the dust and the noise of the machinery.

To set the machinery in place, we have spruce deals from 10 ins. to 12 ins. square, which belong to the plant and are used for supporting the plant. These deals are much preferable to planks placed on top of each other.

The ground must be levelled, then the deals must be set down and the portable engine and boiler placed on top of them. The machinery is all set plumb with a level, and in a straight line by means of a rope. The wheels must be blocked. In order to avoid all trouble, it is wise to see to it frequently that the machines are plumb. When the machines are out of plumb, this can easily be remedied by means of wooden wedges.

Care of Boilers.—For the care of the boiler and of the roller, we give the men special illustrated instructions. As this is the most important part of the machinery, we insist upon having these instructions carried out to the letter, and the results obtained since we have inaugurated this system are surprising, so far as fuel saving and repairs are concerned. It is the instructor's duty to watch and also to help when the boilers are cleaned each week. He must also be familiar with the working of the machines, he must help to cast babbitt bearings if necessary, help to tighten the bolts of the boiler, and to block all leaks through which steam is escaping. While the work is going on, he must be able to know if the machines are in good order by the noise they make. He must be familiar with the working of the pumps, injectors, etc.

The boiler and roller engineers must have a certificate of competence. They must carry out to the letter written instructions, given them by the department, with reference to the most economical way of heating. (Heating a boiler full of cold water too quickly would be sure to cause its early destruction.) They must see to it that they have sufficient water and that the supply is regular and constant; they must take care of monometers, test the safety valves at least once a day, know how to put out the fire should the water become low in the boiler, and know how to empty the boiler properly.

The boiler and engine are always under shelter of a portable shed, which is large enough to be able to hold oil, straps, belts, spare parts, etc. This shed is also used as shelter for the men during showers, but it is required especially to keep the machines free from the dust coming from the stone-crusher. This dust would rapidly damage the bearings and the shafts.

Road Roller.—To keep a roller in good order its boiler requires more attention than does the portable boiler, because the roller is always moving. The driver must especially look after the tubes of the boiler; if they leak, he has a tube expander which enables him to repair them very quickly. He must clean his machine every morning, and while making steam, clean all the mechanical parts such as the oilers, the grease cups, etc.; see that the bolts are tightened; see that there is no part worn out, and see that the exhaust is working well. The exhaust is sometimes blocked by rust, and trouble results.

The roller driver must look after the eccentrics, pistons and packings. When scarifiers are attached, the instructor must not forget to remove the scrapers from the wheels. This is very often overlooked, and then the scrapers are broken. The boiler tubes must be cleaned every day. A roller should never be placed in the hands of an inexperienced operator. Speeds should not be changed roughly, but only when the roller is stopped. This will prevent the slide of the eccentric from spreading.

Stone-crusher.—After ground has been levelled, deals are set in exactly the same manner as for the boiler. The crusher is placed perfectly level. Owing to the vibration, it should be set down solidly and should be levelled very often. Under the bottom part of the elevator, a hole must be dug large enough to facilitate the removal of the stones which fall out of the buckets. It is preferable to surround this hole with wood so as to prevent the earth from sliding.

The crusher requires particular attention, especially so far as oiling and greasing are concerned. The grease cups must be cleansed with gasoline, as this machine is always working in a cloud of dust, which makes the grease cups and oil-cans dirty very quickly, and prevents the oil and grease from reaching the bearings. The bearings of the connecting rod must be well connected with the crank and must be renewed properly. The department gives written instructions, with plans and sketches.

When the crusher is in operation, the instructor must prevent the men from using sledge-hammers on stones which are a little too big to go between the jaws. It sometimes happens that by using these hammers the jaws are broken. Sometimes the hammer drops in, thus breaking the jaws or the deals on which the crusher is set.

Elevator, Screen and Bin.—The elevator chain which holds the buckets must be greased often. If this is neglected it will wear out quickly and cut the teeth of the sprockets. The grease cups of the bearings of the revolving screen must be cleaned and filled with oil every day, as well as the teeth of the gears. The bin, like the other machines, must be set plumb, on deals. The screen sorts out the different sizes of stone, according to the specifications. During that time all the stone and dust in the

screen is mixed like concrete in a concrete mixer. A large quantity of fine dust is taken up by the wind, and sometimes spoils neighboring properties. To avoid this loss, a light framework is put over the bin, covered with cotton or linen.

It is economical to build a large platform close to the crusher, so as to enable wagons to haul the stone up to the level of the opening of the crusher. This reduces the cost of handling.

Sprinkler.—The sprinkler is used for distributing the water necessary for cementing the stones during the last operation of the construction of water-bound macadam. There is a pump attached to the sprinkler, but as this method of filling takes considerable time, it is preferable to use an auxiliary gasoline engine with pump and tank.

The tank is placed on a solid frame 6 or 7 feet high, near the part of the road that is under construction, and it feeds through a 3-inch pipe and valve. By this system the sprinkler is filled in a few minutes, there is always enough water on the road to do good work, and the roller is never behind.

A plant which is not so organized as to have plenty of water at all times, does poor and expensive work. If there is plenty of water and it is close to the machines, it would be cheaper to take the pump off the sprinkler and put it on the boiler, and it will then only be necessary to have a tank.

We have adopted a new arrangement for that part of the sprinkler which distributes the water. The old arrangement was too heavy and subject to frequent breakage, the cost of repairs each time being high. The new arrangement is much lighter, costs less and does not break. Iron wheels are replaced by wooden wheels, which are much preferable. The gear of the front wheels is arranged in such manner that it can turn completely under the sprinkler tank. In this way the sprinkler can turn in a very limited space without destroying the macadam.

Grader and Drag.—With each plant there is a road grader which is drawn by horses; but it is used cheaply and advantageously when attached to the steam roller. In rural municipalities it is hard to find teams to give continuous time to this kind of work. With this machine, the road can be put in form, the roadbed made, the shoulders levelled, and, in some places, the ditches cleaned, much cheaper and quicker than with a shovel or an ordinary plough, and the work is done much better. It is necessary to have had experience to be able to use this machine, and we therefore recommend choosing a good man and always taking the same man, so as to give him more experience. The department gives to municipalities instructions as to how to make earth roads with the grader, and illustrations showing how to use the split-log drag, which should be used after the road has been put in form with the grader.

During the construction of the Levis-Jackman road, a split-log drag was used to spread the gravel dumped from the wagons, and to keep in form the road which was being rolled. It was also used to advantage in the maintenance of the road, which was divided into sections of 4 to 5 miles in length. A sectionman was appointed to look after each section. When the department deemed it advisable, after a storm especially, it gave instructions to the sectionman by telephone, to pass the split-log drag over the section of which he was in charge. In this manner the drag was passed over the whole road on the same day. The superintendent would go over the road in an automobile, seeing that every one was on the job, etc. The instructions given by the department to the sectionmen were to pass first on the side, close to the ditch, to level the shoulder, and on the second turn to pass the drag towards the centre, so as to bring the loose gravel on the road towards the centre. This makes the surface of the road very even, fills in small ruts and holes, and facilitates drainage in rainy weather. The ruts made by the wheels and the tracks made by the horses are scraped off, so that the teams do not always pass in the same place. Thus the wear of the road is more evenly divided.

Generally a gravel road, well-rolled and cemented, is so hard that it is impossible for the drag to give it a crown when it has been broken up. In that case, the grader must be used early in the spring; that is, as the earth begins to thaw, and before it hardens. Despite the rolling, certain qualities of gravel take a long time to bind. In this case, the use of the drag is necessary, so as to keep the crown of the road until it is completely cemented. The sectionman must carry a shovel, and if he discovers a rut or a hole which the drag cannot fill, he can use his shovel to fill it. During the years 1914 and 1915, split-log drags were used for the maintenance of the Levis-Jackman road. One man, with two horses weighing 1,300 lbs. each, can scrape in one day a section 4½ to 5 miles long.

The department has distributed to municipalities an illustrated circular showing how to use the split-log drag.

On the road leading to Valcartier, at the request of the Federal Government late in 1914, the department took charge of the maintenance over a length of nearly 5 miles. The soil was sandy and of the hardest variety for an earth road. After having put the road in form with the grader, it was kept in good order by using the split-log drag, although there was a heavy traffic of automobiles, trucks and other vehicles. All the heavy artillery passed over this road. I passed a few minutes after some of the big guns. The heavy loads were pulled at a gallop, yet the road was not in very bad condition; there were at the most five or six ruts. Generally it is thought that when the drag has gone over the road once, that it has been repaired for the whole season. This is a serious error, because, in order to obtain the best results, the drag must be used often, especially when the weather conditions are most favorable; that is, after a rain, not when the earth is all wet and muddy, but just as it begins to dry and before it becomes hard.

Experience teaches us that an earth road maintained by a split-log drag will not reach its maximum of perfection until after three years. The split-log drag was first used in 1853.

Pick Plow.—The plant has also a pick plow, which is used to tear up old macadam or to break up the ground.

In a paper entitled "Top Contact Unprotected Conductor Rail for 600-volt Traction Systems," Mr. Charles H. Jones says: The conductivity of the rail will vary inversely with the percentage of carbon or manganese allowed to remain in it. The ordinary run of Bessemer rail has a conductivity of about one-tenth that of copper, while a rail with a low percentage of carbon has a conductivity one-eighth that of copper representing an increase of about 25 per cent. in conductivity. The price increases from 18 per cent. to 20 per cent. Increasing the conductivity makes the rail considerably softer, thus requiring more careful handling to prevent it from being kinked during installation. There is no appreciable difference in the rate of wear between the low carbon and ordinary steel in the class of service referred to in this paper. Nothing is to be gained by using a rail weighing less than 80 lb. Above 80 lb. the question requires careful consideration, since the gain in conductivity will cost almost as much as equivalent conductivity obtained by adding to the copper in the feeding system paralleling the rail.

SEWAGE DISPOSAL BY THE ACTIVATED SLUDGE PROCESS.*

By T. Chalkley Hatton, M.Am.Soc.C.E.,
Chief Engineer, Milwaukee Sewerage Commission.

At the May meeting in 1914 of the Manchester Section of the Society of Chemical Industry of Great Britain, Messrs. Ardern and Lockett published the first notice that a new process of sewage treatment was being developed by them with great promise of success. They termed it "M 7." Shortly after the paper was published the process was mentioned in England as the "live earth" process, but when it reached America it was given the name of "activated sludge," as representative of the usual American expressiveness.

Professor Phelps, of the Massachusetts Institute of Technology, and Col. Black, of the U.S. Army, had been making, about this time, some very interesting experiments on enforced aeration in connection with their studies of the sewage disposal problem for the City of New York, the results of which indicated that enforced aeration might be used with advantage to remove the major portion of the suspended solids from the New York sewage and thus secure sufficient clarification to discharge the effluent into the harbor without appreciable nuisance.

In fact, for a great many years investigators from time to time have been experimenting with sewage treatment by means of enforced or natural aeration, and with more or less success. The modern percolating or sprinkling filter is but a form of enforced aeration by which the oxidation of the organic matters contained in the sewage is accelerated, and the nitrifying organisms are given that excess oxygen necessary for performing their best work.

But until the development of the "activated sludge" process the virtue in the sludge itself was never recognized. In all other processes the aim has been to separate the suspended matters as quickly as possible from the sewage, reduce them to the form of sludge, and then get rid of the sludge without bringing the two into further contact.

Plain sedimentation, chemical precipitation, septic process and the Imhoff tank fermentation process are all based upon a complete separation, so far as possible, of the solids from the sewage and within the shortest time. On the other hand, the activated sludge process aims to keep the sludge in the most intimate contact with the sewage throughout the whole period of treatment up to the point of final sedimentation; most of the purification having been effected when the process reaches this point.

Every sewage treatment investigator knew that fresh sludge contained myriads of reducing and nitrifying bacteria, but it remained for Dr. Fowler to discover the art of making those bacteria contained in the sludge produced from one day's sewage to separate from and turn into willing co-workers the bacteria contained in the next day's sewage, thus separating from the sewage itself the very medium which nature has provided for its ultimate purification and intensifying the numbers and work of such media, so that the purification may be accomplished in the shortest time.

Knowing, as we now do, that all organic matter is finally reduced to some form of mineral matter through decomposition, and that this decomposition is accomplished by micro-organisms of many kinds provided by nature for the ultimate protection of mankind, it seems quite logical to use artificial means to create and multiply such micro-organisms to the fullest extent to reduce as quickly as possible the filthy organic matter produced by the human body. Now, this is just what the activated sludge process aims to do.

With a sewage containing, say, one million bacteria per cubic centimeter it will produce sterility, if carried out to its ultimate possibilities, and these bacteria, so separated, will become attached to the flocculent sludge, every particle of which is in intimate contact with the sewage as it passes through the aerating tanks, until it contains from 15 to 20 millions bacteria per cubic centimeter, and when the sludge reaches this activated condition good purification is bound to result.

Let us stop here just a moment to consider the character of those bacteria which, it is believed, perform the major part of the purification. There are at least three classes of bacteria which are known to be highly efficient in reducing organic matter if given their natural environments: anaerobic, aerobic and facultative. The first exists and works in the absence of oxygen. The second, to do its best work, must have a plentiful supply of oxygen, while the third partakes of the nature of both of the others and can work either with or without oxygen.

Plain sedimentation, chemical precipitation, septic and Imhoff tank processes use the anaerobic and facultative bacteria which reduce the organic matters by fermentation processes, and thus produce odors to a greater or less extent.

Percolating or sprinkling filters, sand filters, contact beds, land treatment and activated sludge process use the aerobic and facultative aerobic bacteria and thus produce no odors. Those of you who have smelled the odors from a sprinkling filter are likely to doubt this statement, but consider that the influent fed to the modern sprinkling filter has first passed through an anaerobic process of some kind which has started fermentation which must be overcome before the aerobic bacteria can reduce or dissolve the odors.

Therefore, in the modern sprinkling system, the two processes of sedimentation and aeration are diametrically opposed to each other, and therefore the highest efficiency cannot be expected.

The activated sludge process consists of surrounding the aerobic and facultative aerobic bacteria with those natural environments which produce an intensified creative and working power, and it is the only process, except land treatment, producing a similar effluent wherein the sewage is given but one treatment.

The raw, coarse, screened sewage is run into and through a tank which contains a certain quantity of activated sludge. During its passage this sludge is intimately mixed with the sewage by means of air in the form of small bubbles forced through the mixture.

A small portion of this air is consumed by the mixture of sludge and sewage, but the major portion passes off unused except for its mechanical power. It is believed that the colloids contained in the sewage are largely removed by the scrubbing action due to the violent disturbance of the liquid, and are absorbed by the activated sludge. Whether this is or is not the manner in which the colloids are removed it is true that the process produces a sparkling effluent long before nitrification occurs.

After the sewage has been in intimate contact with the activated sludge for a certain period (depending entirely upon the character of effluent required), it passes

*Abstract of a paper read before the Fifth Annual Meeting of the Ontario Health Officers' Association, May 31st, 1915.

into a final sedimentation tank, carrying with it such portion of the sludge as may be mixed with it.

Owing to the flocculent nature of this sludge most of it settles very rapidly to the bottom of this tank from which the clarified liquor passes to its ultimate point of disposal. That portion of the sludge which settles in the sedimentation tank is highly activated, and in order to keep the aerating tanks constantly supplied with the proper proportion of activated sludge, some of it must be returned to the raw sewage as it enters the aerating tanks, the balance must be removed at frequent intervals in order to maintain the proper sedimentation area in the tank and to prevent septic action which occurs if sludge of this character is subjected to anaerobic influences, as it would be in the bottom of a deep tank.

One of the primary features of this process is that it is susceptible of producing any standard of effluent required to meet the local conditions, and its first operating costs are almost directly proportional to the degree of purification demanded. The three principal items which affect the degree of purification and the cost are volume of air, period of aeration and volume of activated sludge required in the mixture. The greater the volume of air per gallon of sewage treated the greater the fuel cost. The longer the period of aeration and the greater the volume of activated sludge required in the aeration chamber, the greater the size of the tanks and their first cost.

One of the most comprehensive statements of the results obtained by variation in volume of air mixed with the sewage is that published by Mr. E. E. Sands, city engineer, in his report of his experiments conducted for the city of Houston, Texas, issued February 1, 1916, and from which the following table is extracted in brief:—

Table I.

Table Extracted from Page 44 of Mr. E. E. Sands' Report on Sewage Disposal for the City of Houston, Tex.

Item.	Crude sewage, parts per million.	Percentage of removal in 1 hr.	2 hrs.	3 hrs.	4 hrs.
Total organic nitrogen	5.5	64	65	66	67
Free ammonia	[illegible]	[illegible]	82	[illegible]	95
Dissolved oxygen consumed	[illegible]	97	[illegible]	[illegible]	[illegible]
Suspended matters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nitrites and nitrates	Trace	4	8	10	11
Bacteria at 20° C. per c.c. ..	2,800,000	93.7	95.8	95.8	95.8

These results are averages from a large number of samples. The aerating tanks contained from 20 per cent. to 30 per cent. of activated sludge, and the mixture of sewage and sludge was treated with 0.437 cubic feet of free air per hour per gallon of sewage.

Diagnosing this statement it can be plainly distinguished that in Mr. Sands' experiments the clarification and bug removal were effected in the first hour with less than one-half cubic foot of free air per gallon of sewage treated; but it required four hours to reduce the free ammonia to nitrates. In other words, if a clear effluent with few bugs fit the local conditions one hour's aeration is all that is required, whereas if a stable effluent is demanded, four hours' aeration must be given.

From this statement it must not be concluded that in order to secure the results shown in Mr. Sands' statement for the first hour all that is necessary is to furnish 0.437 cubic feet of free air and aerate the sewage one hour, because this small volume of air and short period of aeration would soon impoverish the activated sludge which requires much more air than the raw sewage if the process is to be uniformly maintained.

While Mr. Sands makes no statement of this fact in his report, he has made provision for this in the large plant which he has recently designed for treating the sewage of the city of Houston by the activated sludge process wherein he provides for an average aeration period of one hour and fifty minutes for the sewage and four hours and thirty minutes for the sludge.

The investigations in Milwaukee upon the changes occurring in the sewage during the process gave somewhat similar results to those secured at Houston, although they were not as rapid.

The following table shows the average results obtained:—

Table II.

Statement of Certain Characteristics of Activated Sludge Process as Observed at Milwaukee, Wis.

Item.	Crude sewage, parts per million.	Characteristic changes in 1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.
Free ammonia ..	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nitrites	0.12	0.25	[illegible]	1.25	[illegible]	[illegible]
Nitrates	0.09	0.69	1.24	3.28	5.71	7.90
Dissolved oxygen	[illegible]	0.51	[illegible]	[illegible]	[illegible]	[illegible]
Stability in hours	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bacteria at 20° C. per c.c.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The aerating tanks contained from 20% to 30% of activated sludge. The sewage was treated with 0.375 cu. feet of free air per hour per gallon of sewage.

Attention is particularly called to two or three things appearing in Table II., *viz.*:—

The progressive steps required to convert the free ammonia into nitrites and finally into nitrates. How little is accomplished the first and second hours, and how much during the third, fourth and fifth hours. Following this characteristic is the rapid increase in dissolved oxygen and the stability of the liquor, indicating pretty clearly that if a stable effluent is required good nitrification must be established.

The greatest effect upon bacterial removal occurs during the first hour. This is doubtless due to two things: the rapid digestion powers of the organisms in the activated sludge, and the flocculent character of the sludge to which these bacteria naturally adhere, just as they do in the floc produced by chemical precipitation.

The amount of activated sludge mixed with the raw sewage as it is being aerated affects the degree of purification to an important extent. To obtain an equal standard of effluent, if the sludge volume is reduced the volume of air must be correspondingly increased and the period of aeration. The Milwaukee experiments indicate that a clear and stable effluent can be obtained from the Milwaukee sewage by mixing from 20 to 25 per cent. of activated sludge for four hours with about 1.75 cubic feet of free air per gallon of sewage treated.

As the sludge is precipitated to the bottom of the sedimentation tank it contains approximately 98 to 99 per cent. water; therefore, to get a mixture of 25 per cent. of sludge back into the aerating chamber a volume equal to about 40 per cent. of the raw sewage must be returned; that is, the mixture of sewage and sludge passing through the aerating chamber will approximate 140 per cent. of the raw sewage being treated. This fact must not be lost sight of in determining the size of the aerating chambers in allowing for a certain period of detention.

In order to determine the percentage of sludge in the aerating chamber the Milwaukee practice has been to fill a calibrated tube with the mixture, and at the end of one-half hour determine by volume the percentage of sludge settled.

One of the important features of this process is the proper design of the sedimentation tanks. The sludge is

quite different in character to that produced from any other sewage treatment process. If allowed to come to rest in a test tube or bottle 95 per cent. will settle out in five minutes, but there is a very fine floc of a low specific gravity which remains in suspension for a much longer period, and if disturbed by the slightest current will continue in suspension.

This fine floc, with much of the coarser light floc, will remain in suspension in a properly designed tank in the form of a sludge blanket which can be maintained with its surface within six inches to one foot below the surface of the liquor in the tank. If the influent is discharged into the tank a few feet below the surface of this blanket so as to produce an upward velocity of not over 12 to 16 feet per hour the fine floc will be caught and retained by the blanket and prevented from passing out with the effluent.

It is therefore believed that the vertical upward flow sedimentation tanks producing slow velocities with ample capacity for precipitated sludge are far more applicable for satisfactory operation than horizontal flow tanks, and that the sludge blanket above referred to is essential if clear effluent is desired.

In Milwaukee many experiments have been made to determine the best apparatus and method for diffusing the air through the mixture of raw sewage and sludge. So far the "filtros" plate as manufactured by the General Filtration Company, of Rochester, New York, appears to be the best media, but we believe this can be greatly improved. As now manufactured, the uniformity of porosity is not satisfactory and the loss in friction of the air passing through the plate is too great. This company is now carrying out a line of experiments to correct these difficulties.

We have been experimenting recently with a wooden block cut across grain from basswood which appears to give some promise. There is no doubt, however, as the demand for a satisfactory diffuser grows greater such a one will be produced.

Some experimenters suggest a perforated pipe for diffusing the air. We have tried that experiment pretty thoroughly, and while very satisfactory results were obtained, it required much more air and longer period of aeration to secure the same amount of nitrification. If the filtros plate, or other type of diffuser is likely to cause serious trouble to maintain, it may be less expensive to use the perforated pipe even though more air is required.

Many queries have been received as to whether these diffusers become stopped up by the dust carried in the air or by absorption of the sludge. In answer to this it might be said that, after nine months continuous use in Milwaukee we find no evidence of such stoppage, although all the air supplied to the diffusers passes through a wood wool filter, and the blower producing the air is so designed that no lubricating oil can reach the air discharge pipe.

One of the difficulties we have found should be mentioned. The heavier sludge, composed of wastes, small pieces of leather, hair and entrails from the packing houses accumulate in masses and settle upon the surface of the diffusers until the air builds up enough to partially remove them. This has required the removal of these large masses by hand at infrequent intervals. It is a matter which must be considered in operating this process, and to overcome the difficulty it may prove desirable to pass the raw sewage through medium fine screens, although fine screens are to be avoided if possible.

In an American industrial city those employed in machine shops seem to be very profligate with waste. This appears to be particularly true in Milwaukee where, from one intercepting sewer, there has been removed from the coarse bar screens, during five hours a bushel basket half-full of waste. This material has been one of the most troublesome to deal with in all processes of sewage treatment. An educational campaign amongst the shops might partially correct the difficulty.

Whether this heavy sludge which now remains near the bottom of the aerating tanks can be more effectually lifted and mixed with the whole body of the sewage by inserting vertical cross baffles in the tanks is a matter now being investigated. It may be such baffles will play a quite important part in more thoroughly mixing the sludge and sewage by the expenditure of less air. The fundamental principle of the aerating tank is thorough mixing and practical means of accomplishing this result will add to the efficiency of the tank.

The sludge disposal problem has been the most difficult one to solve in all modern sewage treatment plants, and it was a specially hard one for Milwaukee until the activated sludge process was developed, because there is absolutely no waste ground in or around the city upon which sludge could be deposited, and while, for a few years perhaps, it might be dumped into the lake several miles from shore, it is to be devoutly hoped that the Federal Government will shortly prohibit this method of sludge disposal in all fresh water under its jurisdiction.

One only has to inspect a few of the more modern sewage disposal plants in England to realize what a problem the disposal of sludge is bound to become if we must depend upon wasting it. Fresh or dried sewage sludge is not a thing of beauty under the most favorable conditions, and it does give off more or less unpleasant odors. No one desires it upon or nearby his property, and unfortunately it keeps producing every day in the year until its disposal becomes a nightmare to those responsible for its disposition.

So far, sludges produced from plain sedimentation, chemical precipitation, septic and Imhoff tanks have contained so little ammonia, phosphoric acid, and potash, that their value as a fertilizer is too small to warrant the cost of reduction, although it is true that during the favorable seasons of the year farmers can be induced to take some sludges as tankage, but, on the whole, such disposition cannot be relied upon and so far no profit worth noting has been made from it either in Europe or America.

It is believed by us in Milwaukee that this new process has solved the sludge disposal problem advantageously even to the smaller cities. During our experiments a large number of sludge analyses have been made, not only by our own chemists, but by those in the fertilizer departments of the Chicago Packing Companies, and these have all shown a high value available as a fertilizer. The following is a representative analysis with the commercial values set forth as given by those in the employ of the fertilizer producers:—

Analysis of Activated Sludge, Milwaukee.

Ingredients.	% dry basis.	Pounds per ton.	Value per ton.	Total value.
Fats	2.00	40.0	$ .04	$ 1.60
Available phos. acid	1.66	33.2	.005	.17
Insol. phos. acid ...	0.54	10.8	....	.....
Total phos. acid	2.20	44.0	....	.....
Nitrogen	5.71	114.2	....	.....
Ammonia	6.94	138.8	.10	13.88
Potash	0.43	8.6	.03	.26
				$15.91

The apparent value of this sludge is $15.01, but the writer believes from the information secured from the fertilizer producers, the only real value to the city of Milwaukee will be the available ammonia, upon the basis of which the dried sludge will be sold. This amounts to $13.88, but because of the probable variation in the ammonia content, and in order to be conservative, he has estimated an average value of $12 per dry ton.

Where sludges contain less than 10 per cent. of fat its value hardly pays for the cost of extraction, and such a quantity does not injure the sludge for a fertilizer.

The Milwaukee sewage produces from 3,000 to 5,000 gallons of sludge per million gallons of sewage treated, and when removed from the sedimentation tanks contains from 97 per cent. to 99 per cent. of water. About one-half a ton of dried sludge is produced from this volume of sludge or one-half ton of marketable fertilizer per million gallons of sewage treated. It is, therefore, believed the sludge can be sold for $6 per million gallons of sewage treated.

At the present time we are experimenting with a Berrigan press manufactured by H. R. Worthington, of Harrison, New Jersey, and find no difficulty in dewatering this sludge to 74 per cent. moisture. Mr. Winthrop R. Pratt at Cleveland is also experimenting with a centrifuging machine of the laundry type, and so far appears to be securing promising results. In neither case has it been found necessary to use lime, or other substance, in pressing this sludge to an one-inch thick cake.

While its further dewatering through direct or indirect driers has not been tried out by us, there seems to be no doubt from the daily experience of the Chicago packing houses in the drying of their tankage and liquid manure that this sludge can be quite as easily and economically dewatered to 10 per cent. basis, which is the moisture content allowable in fertilizer. In fact there are several driers in use in many industrial establishments which are satisfactorily operating on a similar material, and the writer has secured from some of the manufacturers of driers guarantees which cover the cost of drying the sludge we are producing from 80 per cent. to 10 per cent. moisture, exclusive of handling.

While we have not completed our dewatering experiments we have secured sufficient information to warrant us in believing that $6 per dry ton will cover the cost of dewatering and shipping the material to Chicago, including overhead charges.

Estimating the average value of the marketable sludge to be $12 per ton, there will be a profit of approximately $3 per million gallons of sewage treated.

I appreciate that these are estimates only, and the public will look upon them as such, and while we in Milwaukee are much concerned in getting all the profit possible from the sludge, we are primarily more concerned in finally disposing of the sludge without nuisance, even though no profit is realized.

That the sludge is valuable as a fertilizer has been physically proven by Dr. Edward Bartow, Director of Illinois State Water Survey, in his laboratory at the State University, where he made several pot cultures of wheat and garden vegetables according to the standard method employed by the United States Agricultural Department.

The writer has gone into the sludge question in considerable detail because of the doubt expressed by so many interested parties that the sludge can be successfully disposed of. There is great reason for this doubt, because in no other artificial process of sewage disposal has it been possible to dispose of the sludge without expense and growing nuisance.

Two of the important features which appeal not only to the engineer, but to the average layman are the low first cost of installing the activated sludge process and the high standard effluent procurable.

So far as the writer knows, the only artificial process which produces an effluent at all comparable with the activated sludge process is sedimentation, followed by percolating filters and final sedimentation with sterilization.

The first cost of the activated sludge process is practically the same as the first cost of sedimentation tanks of the Imhoff type of like capacity. The cost of the percolating filters, final sedimentation and sterilizing equipment must be added. This cost is approximately $14,000 per million gallons of sewage treated. This adds largely to the overhead charges. In addition to this the cost of sterilization must be considered. We have found in Milwaukee that it costs $2.50 per million gallons to sterilize the effluent from an 8-foot deep sprinkling filter to the same standard of bug removal as secured by the activated sludge process.

The activated sludge process requires one acre to treat ten million gallons, whereas the sprinkling filter process requires five times as much. Available lands in or near a city are expensive, and this additional cost must be considered.

ULTRA-VIOLET RAY STERILIZER IN CANADIAN BOTTLING PLANT.

Probably the first non-portable ultra-violet ray water sterilizing outfit installed in Canada was at the York Springs bottling plant, near Toronto.

The water supply is obtained from five springs at York Mills. These springs are within a few hundred feet of each other, and the water flows by gravity to the bottling plant, which is built in a hollow or ravine. They have a capacity of 14,000 gallons per 24 hours. The water flows into a concrete cistern, from which it is pumped to the first upper story of the plant. There it is filtered, under pressure, through three small filters of about 1,000 gallons per hour total capacity. From the filters the water passes to two slate tanks which act as reservoirs. From these tanks it flows by gravity through an E2 type R.U.V. special casting, and is sterilized by a single lamp, which operates on a 230-volt d.c. line, 2.2 amperes.

The sterilizer has a capacity of about 1,000 gallons an hour, but is operated at only 700 gallons per hour. From the sterilizer the water passes by gravity direct to the bottling, aerating and flavoring machines. Daily samples for bacteria count are taken from the pipe line just ahead of and just after the sterilizer, to check its operation, although the management state that this precaution has not proven necessary to date, as the water has shown a low bacteria count with no pathogenic organisms, even before sterilization. The sterilizer was deemed advisable, however, as an extra safeguard.

Mr. P. A. Boeck, in a paper before the Chicago Section of the American Society of Mechanical Engineers, suggested that since heat was a form of energy consisting of molecular vibration of a periodic character, the introduction in a furnace wall of bricks of different density would help to break up or change the wave length. Layers of insulating powder may also be used, or air spaces; but care should be exercised in this application of the last named, as large voids have the effect of propagating heat by convection and radiation.

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS.*

Reviewed by Mr. T. H. Hogg.

Assistant Hydraulic Engineer, Ontario Hydro-Electric Power Commission.

THE report on the Winnipeg River Power and Storage Investigations, published as Water Resources Paper No. 3 by the Dominion Water Power Branch in connection with its administration of the water powers of Manitoba, Alberta, Saskatchewan and the Northwest Territories, will be received with interest by both the engineering profession and the public in general.

The hydro-electric development installed by the city of Winnipeg a few years ago directed attention in a measure towards the power resources of the Winnipeg River. This, together with the publicity given the proposed development of the Winnipeg Street Railway at Great Falls, has focused a good deal of attention on the potential possibilities of the river.

The report has been prepared by Mr. J. T. Johnston, chief hydraulic engineer of the Dominion Water Power Branch, acting under the direction of Mr. J. B. Challies, superintendent. It covers investigations carried on since 1911 by the Branch, on the power possibilities of the Winnipeg River in Manitoba, undertaken with a view to devising a consistent scheme of water power development, and to allow the drafting of a general policy under which such a scheme might be carried out. Mr. J. R. Freeman, of Providence, R.I., and Mr. J. B. McRae, of Ottawa, advised on the organization and scope of the surveys, the latter being retained to act as consulting engineer throughout the full period of field and office investigations.

The report comprises two volumes—Volume I. of about 370 pages, containing the text, and Volume II. the topographic field plans. The text begins with a summary of the investigations, followed by a description of the Winnipeg River watershed and the field investigations covered. Following a discussion of meteorological and run-off phenomena is a critical analysis covering the possible means of obtaining, by storage, the flow required for the ultimate development of the total power possibilities of the river. A full chapter is devoted to a description of the existing power and industrial plants. Following this, each of the possible power concentrations are described in detail, giving costs. To compare the cost of power obtained from coal, gas and oil, with hydro-electric power, estimates are given for the cost of fuel power in Winnipeg and the cost of hydro-electric power developed at one of the sites and transmitted to the city.

A section is devoted to a discussion of the present and future market for power in Manitoba, and the report closes with an analysis of the influence of the Lake of the Woods and the possible storage there, on the power concentrations as outlined in the report. This discussion is of particular interest in connection with the International Joint Commission reference to the Lake of the Woods levels.

Seven appendices are included, covering the report of Mr. J. B. McRae, the consulting engineer; the proposed development of the Winnipeg River Power Company; a report on the geology of the Winnipeg River watershed by Chas. Camsell; the Dominion water power regulations; list of bench marks; temperature precipitation and evaporation tables, and run-off tables.

*Water Resources Paper No. [illegible] Dominion Water Power Branch, Ottawa.

The report seeks to demonstrate as the principal result of the study undertaken, that a minimum flow of 20,000 cubic feet per second is obtainable at all seasons, with an efficient and systematic control of the run-off, and that it is possible to concentrate practically the total fall of the river in Manitoba at seven power sites, with a minimum output of 175,000 continuous 24-hour power under present conditions of flow, and of 313,000 horse-power with the total river regulation installed. A total ultimate capacity of 420,000 continuous horse-power would thus be available, with the existing plants. It can only be determined by long-term observations of flow, and under operating conditions, whether these figures for the ultimate developments are optimistic, and as to the necessity, if such total developments are installed, of supplementing them by steam or oil auxiliaries, in a succession of years of low flow.

To Manitoba, one of the finest agricultural districts on the continent, but practically without fuel resources, the above facts are of vital importance. At no distant date the full economic developed capacity of the Winnipeg River will be required. The centre of gravity of the power supply is less than 65 miles from the city of Winnipeg and within easy transmission distance of the larger demand centres of the province.

Estimates of cost at each possible site have been prepared in detail. These costs, which have been made up on the basis of low-tension power at the power house switchboard, should prove most attractive, both from the viewpoint of the capitalist looking for investment, and from that of the consumer who desires cheap power. The average capital cost of the total final output of the seven power concentrations is $42.80 per horse-power, based on machinery installed, with an annual cost per horse-power of from $4.50 to $5.50 per horse-power-year. The capacity of installed machinery is based on 50 per cent. excess over the continuous capacity of the sites, at 75 per cent. overall efficiency. These estimates show careful preparation and appear to be conservative, the large capacities involved and the geological and topographical features of the power sites being responsible in a large measure for the extremely low costs. No charge is included for the operation of the necessary storage dams of the ultimate developments, and the power rentals to the government are omitted.

The value of the data collected and presented in this report need not be emphasized to the engineer. Too many failures exist as monuments to the lack of sufficient information necessary for adequate design. The acceptance of a unified power development scheme for the whole river, and the establishment of the necessary authority for the supervisory control preparatory to development of a particular site, is the only way in which the full measure of the power resources of the Winnipeg River may be realized.

The necessary storage for the ultimate developments must be secured on the headwaters of the river in the Province of Ontario. Necessarily, as the report suggests, some independent government board, such as joint control by the Hydro-Electric Power Commission of Ontario and the Dominion Water Power Branch, must exercise supervision. Independent control will be necessary also for the regulation of local pondage, as control by conflicting and independent interests located at any of the various power sites would almost certainly jeopardize the efficient operation of the plants below.

At all power sites, provision has been made for the future installation of locks, if it is deemed advisable to canalize the river. The feasibility of canalization arises from the fact that slack water will exist practically from

Lake Winnipeg to the Manitoba-Ontario boundary, when the full potentiality of the river has been developed. The navigation features have been fully worked out for the total distance, and have been approved by the engineers of the Dominion Department of Public Works.

One necessary and vital factor for the success of such a scheme of development as outlined, is that the regulations under which the leases are granted are fair and generous to the investor and at the same time protect the public. Lack of space forbids a discussion of the regulations governing the granting of leases; it is sufficient to say that these are eminently fair and should induce capital to invest with guarantees of just treatment on the part of the government.

No review of this volume would be complete without a reference to the policy of the Water Power Branch as outlined in the report. The policy is "to encourage desirable development of water power resources; to discourage and prevent the initiation and development of uneconomic and wasteful projects; to ensure that river systems are developed along comprehensive lines wherein each unit is a component link in a system; to ensure adequate storage measures in the interests of all powers affected; to prevent unnecessary and costly duplication of expenditures on the part of competing plants and dams; to safeguard the public from monopolistic control, by regulation and periodical revision of rates; to see to the early carrying into effect of agreements issued by the department for the development of power; to compel the development of existing plants to their limit when the market demands; and to promote in every way the fullest conservation of the power resources of the West."

The investigations, as outlined in this report, are among the first of their kind to be made by the Dominion Government. The manner of their presentation leaves nothing to be desired; the thorough way in which the field data were obtained, and the concise and interesting manner in which the results are presented are in most refreshing contrast to the ordinary stereotyped departmental report.

To summarize, a comprehensive scheme of water power development to the maximum extent of the unusual power possibilities of the Winnipeg River has been mapped out, and a general policy for the proper control of the same is enunciated, by which the needs of the future can be met, through increased storage and the regulation of run-off. The report reflects great credit on the superintendent and hydraulic engineer of the Dominion Water Power Branch, their officials, and the consulting engineer, Mr. McRae.

It is understood that the present studies will be aggressively continued, since proper future control of the water resources of the river are dependent on continuous hydrographic and meteorological data, on accurate knowledge of storage requirements and possibilities, and upon the compilation of such miscellaneous information as is necessary for proper and economical design.

Companies interested in obtaining accurate information preparatory to financing an individual development on the river will undoubtedly find the greatest use for the report. For the preliminary purposes of finance the information presented is quite sufficient to determine the feasibility of any of the sites for the needs of the interested parties. It should save the usually unavoidable expense of reconnaisance and preliminary survey, often a serious item, and will allow an accurate forecast without loss of time. Should conditions suggest the possible use of sites other than those shown, sufficient information is given in the shape of topographic plans and hydrographic data, to allow the engineer to prepare his own estimates, thus entailing a great saving of expense and time.

From this standpoint alone, the report is amply justified. The result of its publication will doubtless be the acceleration of water power installations on the river, and the consequent development of manufacturing industries which always follows in the wake of cheap power.

Note—We hope to publish very shortly in these columns further articles dealing with the general administrative policy of the Dominion Government with respect to water power administration, with especial reference to the investigations on the Winnipeg River, also dealing with the more technical and engineering features as brought out by the report just issued by the Dominion Water Powers Branch, herein reviewed by Mr. Hogg.—[Editor.]

STANDARD SPECIFICATION FOR CEMENT.

A revised standard specification for Portland cement has been issued by the Canadian Society of Civil Engineers. This specification was adopted by the society at its last annual meeting, the specification having been prepared and recommended by a committee consisting of E. Brown (chairman), J. A. DeCew, Walter J. Francis, P. Gillespie, J. A. Jamieson and G. E. Perley.

The specification requires cement to be delivered in bags each containing 94 lbs. net weight, four bags to constitute a barrel. The bags are to be plainly marked with the net weight of the cement and the name of the manufacturer and the brand of the cement or the name of the mill where it was manufactured.

All tests are to be made in accordance with the American Society of Civil Engineers' report on uniform tests of cement. Detailed instructions for testing cement are appended to the specification.

The required minimum specific gravity is 3.10. The cement must not leave a residue of more than 8 per cent. by weight on a No. 100 sieve, nor more than 25 per cent. by weight on a No. 200 sieve. The cement shall not develop initial set in less than 30 minutes or final set in less than one hour or in more than ten hours. The cement must not contain more than 1.75 per cent. SO_3, nor more than 4 per cent. MgO. The minimum required tensile strengths of briquettes of various ages are tabulated for ready reference.

Copies of the specification are sold at a nominal fee by the society, 176 Mansfield Street, Montreal.

The supply of creosote, because of its use in preserving sleepers, telegraph poles, and other timber employed in railway purposes, is a matter that appertains to railways. It will, therefore, be of interest to know that, according to statistics published by the Bureau of Foreign and Domestic Commerce, the amount of creosote imported into the United States fell from 48,839,020 gallons in 1914 to 34,432,028 gallons in 1915, a decrease of 34 per cent. Owing to the average value per gallon having increased from 6.2 cents to 7.8 cents the imports only decreased 11 per cent. in value. In 1914 33,873,137 gallons came from the United Kingdom, 9,861,996 from Germany, 3,868,786 from Belgium, 777,662 from the Netherlands, 3,000 from Sweden, and 454,-4[illegible] from Canada. In 1915 only four countries were concerned in the supply—the United Kingdom with 31,695,587 gallons, Germany 5,527 gallons, Canada [illegible], and Japan [illegible].

ROADS AND PAVEMENTS DATA FORMS.

THE committee on roads and pavements of the Canadian Society of Civil Engineers has sent out to many highway and city engineers throughout Canada, a form requesting data concerning the construction of pavements. Following are the questions to which answers are requested:

General Information.

Kind of Pavement? Month and Year of Construction?
Province? County? City or Town?
Name of street or road? From? To?
Engineer to Municipality? Present address?
Was work by contract or day labor?
Total width of street allowance? Bearing of street?
Length of pavement? Width? Area in sq. yds.?
Grade of pavement, [illegible] maximum? ordinary?
Crown of pavement, minimum? maximum?
Character of street, residential, manufacturing, business, etc.?
Is pavement shaded or exposed?
Average daily traffic in terms of traffic schedule, before and after improvement?
Details of catch basins, if any?
Cost of pavement per sq. yd., exclusive of subgrade, curb and gutter?

Climatic Conditions.

Summer temperature, maximum? minimum? average?
Winter temperature, maximum? minimum? Average?
Annual rainfall, inches? Annual snowfall, inches?

Subgrade.

Subsoil? Crowned or flat? Watered or dry?
What provision for drainage of subgrade?
Were sewers, watermains, etc., laid before construction of pavement, and if so, for how long?
Location of these with respect to pavement?
Cost of preparing subgrade per sq. yd. of finished pavement?

Foundation.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Binder Course or Cushion.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Surface Course.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Top Dressing.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Curb.

Kind? Width? Depth? Cost per lineal foot?
Materials, proportions, etc.?

Gutter.

Kind? Width? Thickness? Cost per lineal foot?
Materials, proportions, etc.?
Dimensioned sketch of cross section of pavement, photograph also desirable.

Another form is also being sent out to cover maintenance work. The questions on this form are as follows:

GENERAL INFORMATION

(for purposes of identification with previous reports.)

Province? County? City or Town?
Name of street or road? From? To?
Kind of pavement?
Period covered by this Report—From? To?
Date of completion of work?
Date road was opened to traffic?
Has the surface begun to disintegrate, if so what was the cause?
Has the surface become displaced in the form of ruts, waves, etc.?
Is the surface objectionably soft in hot weather?
Is it objectionably slippery at any time, if so, under what conditions?
Has the surface shown undue wear next to curb or track allowance?
During what period covered by this report was the surface covered by snow or ice?
Has the surface been artificially watered?
Has the surface been cleaned, if so to what extent?
Methods of repair?
Methods of maintenance?
Cost of repair per sq. yd.?
Cost of maintenance per sq. yd. of pavement?
Average daily traffic in terms of traffic schedule?

TRAFFIC SCHEDULE.

AT the annual meeting of the Canadian Society of Civil Engineers in January, 1916, the following schedule for the description of traffic was adopted, as simple, comprehensive and adapted for universal use. Each class of traffic is designated by a letter and the degrees of traffic by a number. Combinations of one of the letters and any of the numbers representing degrees of traffic will therefore represent the amount of traffic of that class of vehicle. The sum of two or more of these combinations will then represent the total traffic on any road. The schedule is as follows:—

1. Horse drawn, steel tires	A. Light vehicles	(1) Light—up to 100 (2) Medium—100 to 200 (3) Heavy—200 upwards
	B. Heavy vehicles wagons, trucks	(1) Light—up to 75 (2) Medium—75 to 150 (3) Heavy—150 upwards
2. Self propelled, rubber tires	C. Passenger Automobiles	(1) Light—up to 100 (2) Medium—100 to 400 (3) Heavy—400 to 800 (4) Severe—800 upwards
	D. Motor trucks and buses	(1) Light—up to 10 (2) Medium—10 to 20 (3) Heavy—20 upwards
3. Self propelled, steel tires	E. Steam lorries and tractors	(1) Light—1 (2) Medium—2 to 6 (3) Heavy—6 upwards

Example—The traffic on a road having 150 horse-drawn light vehicles, 80 horse-drawn heavy vehicles and 25 motor trucks, would be indicated by the expression A2 + B2 + D3.

RAILWAY EARNINGS.

The following are the railway earnings for the first two weeks of May:—

Canadian Pacific Railway.

	1916.	1915.	
May 7	$2,7[illegible]	$1,504,000	+ $1,160,000
May 14	2,592,[illegible]	1,604,000	+ 988,000

Grand Trunk Railway.

May 7	$1,030,768	$ 863,195	+ $ 167,573
May 14	1,076,436	922,106	+ 154,330

Canadian Northern Railway.

May 7	$ 677,400	$ 419,600	+ $ 257,800
May 14	748,300	364,800	+ 383,500

POLLUTION OF BOUNDARY WATERS

ENGINEERING INVESTIGATIONS SHOW THAT EXTENSIVE SEWAGE TREATMENT IS REQUIRED ONLY IN THE BUFFALO AND DETROIT DISTRICTS—COARSE SCREENING WILL SUFFICE FOR MOST OTHER BOUNDARY RIVERS.

PROF. EARLE BERNARD PHELPS, consulting sanitary engineer to the International Joint Commission,* has made a report, consisting of 159 large pages and 67 plates, upon remedial measures for the present conditions of pollution of boundary waters between Canada and the United States.

After extensive field work, the Commission issued a progress report, early in 1914, indicating to what extent and by what causes and in what localities the boundary waters have been polluted so as to be injurious to public health. A board of three Canadian and three United States sanitary engineers then compiled fourteen principles which, in their opinion, should guide the commission in its further studies.

Under direction of Prof. Phelps investigations were then undertaken in order to secure data upon which to base a report upon the following question:—

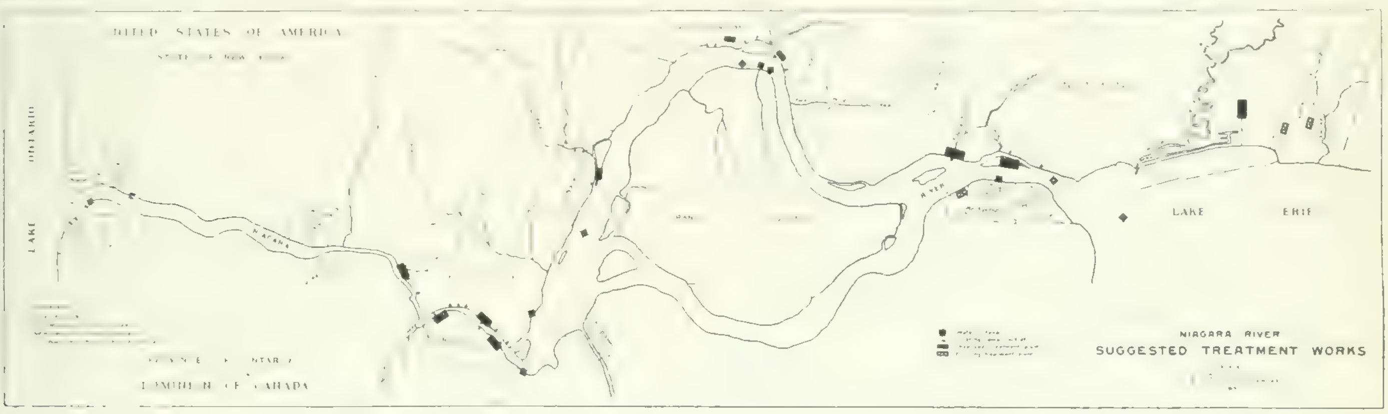


Fig. 1.—Suggested Treatment Works for Niagara River District.

In what way or manner, whether by the construction and operation of suitable drainage canals or plants at convenient points or otherwise, is it possible and advisable to remedy or prevent the pollution of these waters, and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses be best secured and maintained in order to insure the adequate protection and development of all interests involved on both sides of the boundary, and to fulfil the obligations undertaken in Article IV. of the waterways treaty of January 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other?

Stripped of its explanatory matter the reference becomes:

In what way is it possible and advisable to remedy or prevent the pollution of these waters, on either side, to the injury of health or property on the other?

The answer just made is not final. Public hearings will be held at Buffalo June 21st, 1916, and at Detroit June 26th, 1916, at which all interested authorities will have opportunity to present evidence and criticisms. The final conclusions of the commission will probably be based upon its engineers' reports and the evidence produced at the hearings. The following abstracts have been taken from the advance proofs of Prof. Phelps' report:—

Advisability of Remedial Measures.

Satisfactory recommendations upon the advisability of remedial measures must be based on the one hand, upon the results of a thorough examination of existing conditions of pollution; upon the feasibility and cost of remedying these conditions wholly or in part; and upon a careful comparison of the relative value and cost of the benefits to be derived thereby. On the other hand, such an inquiry must be guided in the present reference by the terms of the treaty that the boundary waters "shall not be polluted on either side to the injury of health or property on the other."

It is understood that the advisability of this requirement itself is not in question and that it would be without the scope of the present reference to consider the merits of alternative projects, such as new sources of water supply for the lower communities, which would not accomplish this specific requirement.

It will be necessary, therefore, in this discussion of the advisability of remedies, to review the results already obtained and reported upon by the commission, relative to existing pollution of these waters, and to examine these results with special reference to the nature and extent of any injury to health or property which may be attributed to pollution crossing the boundary.

Such a review involves the interpretation of bacteriological results in terms of injury and necessitates in turn a discussion of reasonable and permissible limits of pollution, the extent and character of pollution from natural drainage, the efficacy of water purification plants, and the effect upon the safe operation of such plants of increasing

*Members of the Commission are:—Canada, Charles A. Magrath, chairman; Henry A. Powell, K.C.; P. B. Mignault, K.C. United States, Obadiah Gardner, chairman; James A. Tawney; R. B. Glenn. Organized in 1912, by treaty, as a court of arbitration to settle all questions regarding boundary waters and other similar frontier matters.

pollution loads. Upon these questions the commission has had the advice of a board of consulting engineers. Upon the basis of these two lines of investigation the bacteriological studies and the engineers' recommendations—it is possible to formulate specific recommendations for a minimum requirement for the treatment of sewage entering the boundary waters. This requirement, however, is expressed in terms of bacteria and organic improvement, and will still permit the application of alternative measures to obtain the desired results. There remains also the question of "possibility" of the required measures, which is interpreted in this case to mean the practical possibility or the feasibility of the projects, having due regard to the engineering phases and to reasonable limits of cost.

[Prof. Phelps' report at this point extensively reviews the report made in 1914, and discusses extent and seasonal distribution of pollution and the significance of the pollution data. An endeavor is made to strike the proper balance of responsibility to be borne by water purification and by sewage treatment.

The minimum allowable treatment in any case is indicated by requiring for raw sewage 4 second-feet of diluting water per capita of contributing population. This requirement is subject to modification by local conditions and by the oxidizing capacity of streams.

Engineering Investigations.

Offices were established at Buffalo and Detroit, in charge of assistant engineers,* and data were collected showing the feasibility and cost of collection and disposal. The results of these investigations are given in great detail in the appendices to the report. It is stated that further studies may develop more economical drainage, and that the treatment suggested is not final, as no study has been made of certain advanced methods that hold promise of further economies.]

The general type of treatment adopted, with suitable local modification, is essentially the same in all cases. It comprises coarse screening for the removal of large floating material, sedimentation in Imhoff tanks, with simultaneous chemical disinfection with chloride of lime. The necessary auxiliary plant, sludge drying beds, chemical mixing tanks, etc., are also provided.

The estimated costs of construction have been treated in the usual manner as invested capital against which an annual charge for depreciation based upon an assumed life (sinking-fund allowance) and an interest charge have been made. This annual charge has been increased by the estimated annual operating expenses to give a total annual expense, and this in turn has been reduced to a per capita basis for purposes of comparison. These figures are set forth in detail in the report. They are summarized in Tables 1, 2 and 3.

The weighted average annual charge for the entire population of the Detroit district is found to be $0.57, for the Buffalo district $0.68, and for the two combined $0.61 per capita per annum. For comparison with this figure it will be of interest and value to determine the total charge for water supply and sewerage in certain cities. Sewage disposal is properly to be regarded as the final step in a complete system which begins with the collection, purification, and distribution of the water supply, includes the collection of domestic and industrial sewage, and ends with the disposal of the sewage. Without water supply there would be no sewage and with water supply, sewers and final disposal are essential. The system, regarded as a whole, is necessary to the well-being of the community; the proper disposal of the final product is a necessary part of the system, and its cost a part of what the community must pay for the benefits of water and sewerage. The statistics of the United States Census Bureau are available for the purpose of this comparison. There are there given the present value and annual operating costs of water supplies and sewerage. In certain cities the cost of disposal is included, but this has been subtracted in the more important cases and the remaining items do not affect the

Table 1.—Summary of Costs and Annual Charges for Sewage Treatment, Detroit District.

City	Population designed for [1]	First cost.	Annual Charges: Fixed.	Operating.	Total.	Per capita
Detroit, Mich. ..	950,000	$5,932,024	$294,901	$215,545	$510,446	0.54
	[2] 2,631,350	12,905,350	635,016	525,445	[2] 1,160,561	.44
Windsor District, Ontario	55,000	392,286	21,291	16,000	37,291	.68
	[2] 110,000	779,187	40,868	25,000	[2] 65,868	.60
Port Huron, Mich.......	25,000	291,135	15,781	9,000	24,781	.99
	[2] 40,000	356,677	19,249	11,000	[2] 30,249	.76
Sarnia, Ontario........	16,000	100,250	5,414	6,000	11,414	.71
St. Clair, Mich.	3,000	28,063	1,620	1,200	2,820	.94
Marine City, Mich. ...	4,000	62,940	3,655	1,700	5,355	1.34
Algonac, Mich	1,700	14,650	928	1,400	2,328	1.37
River Rouge, Mich. ...	15,000	63,635	3,204	4,500	7,704	.51
	[2] 30,000	115,385	6,105	7,000	[2] 13,105	.44
Ecorse, Mich.	4,000	23,078	1,331	1,400	2,731	.68
Ford City, Mich.........	5,000	32,287	1,814	1,600	3,414	.68
Wyandotte, Mich.......	16,000	68,560	3,911	5,000	8,911	.56
	[2] 30,000	101,960	5,714	8,000	[2] 13,714	.46
Trenton, Mich.	1,200	2,650	132	500	632	.53
Amherstberg, Ontario	3,000	17,056	1,079	1,300	2,379	.79
Total..............	1,098,900	.		......	620,206	.565

[1] For treatment. Interceptor designed for greater populations in practically all cases.

[2] These quantities excluded from the totals and general average per capita charge.

Table 2.—Summary of Costs and Annual Charges for Sewage Treatment, Buffalo District.

	Population designed for [1]	Total first cost	Annual charges: Fixed.	Operating	Total	Per capita
Buffalo, N.Y.	600,000	$3,598,751	$203,457	$187,411	$390,868	0.648
Tonawanda, N.Y. ..	11,500	70,685	4,241	6,650	10,891	.947
North Tonawanda, N.Y..	18,000	130,166	7,451	8,900	16,351	.885
La Salle, N.Y.............	3,500	38,648	2,320	1,500	3,820	1.091
Niagara Falls, N.Y.......	69,000	535,950	30,730	28,457	59,187	.857
Niagara Falls, Ontario .	18,000	83,637	5,108	8,960	14,068	.782
Lackawanna, N.Y. [2] ...	16,342	4,000	240	1,200	1,440	.088
Bridgeburg, Ontario [2]	2,110	2,000	120	500	620	.294
When needed.						
Fort Erie, N.Y.	2,000	13,600	816	1,500	2,316	1.16
Kenmore, N.Y.	2,500	10,000	600	1,500	2,100	.84
Chippawa, Ontario	850	28,050	1,680	520	2,200	2.59
Queenston, Ontario.......	300	4,300	258	500	758	2.53
Lewiston, N.Y.	900	5,600	336	500	836	.929
Youngstown, N.Y.	1,000	20,000	1,200	500	1,700	1.07
Total....	746,002	......	......	......	507,155	.68

[1] For treatment. Collectors designed as for population to be expected in 1950.

[2] Additional to existing treatment.

Table 3.—Average Annual Charge Per Capita for Sewage Treatment, Detroit and Buffalo Districts.

	Population	Total annual charges	Per capita annual charges
Detroit district	1,098,900	$620,206	$0.565
Buffalo district	746,002	507,155	.68
Total..	1,844,902	1,127,361	.611

*Detroit River District—H. C. McRae, district engineer; Irving P. Kane, assistant engineer. Niagara River District—F. C. Tolles, district engineer; H. S. Phillips and B. F. Perry, assistant engineers. Acknowledgment is made of valuable assistance by M. E. Brian, Owen McKay, J. J. Newman, Dr. J. W. S. McCullough, Prof. John Amyot, F. A. Dallyn, R. S. Lea, Theodore Lafrenier and other Canadian engineers and health officials.

result materially. An arbitrary interest and depreciation rate of 5 per cent. of the present value has been used, which gives annual charges that are at least not too high. The tabulated figures follow in Table 4:—

Table 4.—Present Value, Operating, Fixed and Total Annual Charges of Water and Sewerage Works in American Cities. (Weighted Average Per Capita.)

Cities with population of—	Present value.	Annual capital charge, 5 per cent.	Annual operation.	Total annual charge.
Over 500 000	50.83	2.54	1.44	3.48
300,000-500,000..	53.31	2.66	1.35	4.01
100,000-300,000	53.12	2.66	1.26	3.92
50,000-100,000 .	44.97	2.25	1.46	3.71
30,000 50,000 ..	43.83	2.19	1.46	3.65
All over 30,000	50.92	2.55	1.39	3.94

In comparison with these costs, which are fairly representative, and, because of their number, subject to less error than those of individual cities, the cost of sewage disposal as a part of this total cost of water and sewerage does not appear to be an unreasonable or disproportionate amount.

Conclusions as to Remedies.

Application of the criterion of effective dilution to the case of the Detroit and Niagara Rivers lead to a certain specified degree of sewage treatment in the two cases. The costs of the required remedial measures have been determined and found to be reasonable in view of the results to be attained, and not disproportionate in view of the general costs of water and sewerage works in American cities. The application of these measures upon these two streams is therefore recommended as both "possible" and "advisable" in the terms of the reference.

Similar studies of cost were also made in the case of the St. Clair River communities upon the same basis of the requirements.

The criterion of effective dilution, applied to this and the other boundary rivers to determine what, if any, sewage treatment is required in each case, showed that except in the case of the Detroit and Niagara Rivers no further treatment is at present required to satisfy the general international requirements. The application of the measures outlined for the St. Clair River, which is the next most seriously polluted stream, is not justified by the evidence of transboundary effect, this stream being in a better condition than that to which it is feasible to bring the Detroit and Niagara Rivers by present-day methods of sewage treatment. This conclusion, however, is of a general nature and must be modified according to each local situation. There must be considered, first, the conclusion of the advisory engineers to the commission, that a minimum requirement for discharge of sewage into these waters should be the removal of gross floating material by coarse screens. Treatment to this extent is indicated wholly upon the grounds of the immediate local effect of sewage discharge in a purely esthetic way. In addition to this minimum requirement, there is also to be considered the proximity of near-by waterworks intakes and the question of so dispersing the sewage throughout the volume of the stream that not only the average conditions may comply with a reasonable criterion of purity, but that the concentration of sewage at any one point or in any one line of flow shall not be excessive. On the other hand, local conditions may determine that concentration of sewage near the shore and location of waterworks intakes in the centre of the stream represents the most economic solution. These are matters which are primarily of local interest and need not, in the first instance at least, come under the general administrative control over these boundary waters from an international standpoint.

In the development of a systematic policy of stream protection, however, it may very well appear that the future requirement of the situation may be best met by bringing the entire control of stream pollution under one administrative organization. Whatever may be the solution of this matter in the case of those streams which are not at present so polluted as to demand remedial treatment under the terms of the treaty, it is evident that the organization responsible for carrying out this work in general must also be responsible for the making of routine observations upon all the boundary waters with sufficient frequency to permit the establishment of the facts of pollution and of its extent with increasing population, and to indicate the future need of remedial requirements sufficiently in advance of their actual necessity to permit proper engineering studies and the construction of the necessary works. In this sense, therefore, the jurisdiction of whatever administrative body may be appointed to take charge of this work should be coextensive with the entire system of boundary waters. In the case of the St. Clair River, the detailed engineering studies already alluded to

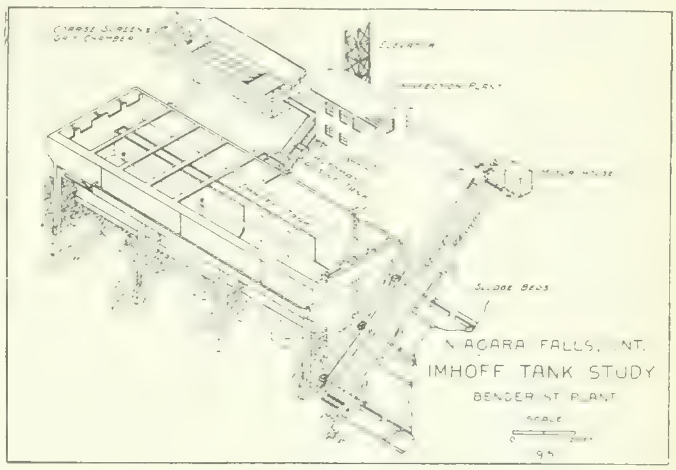


Fig. 2.—Typical Suggested Treatment Plant.

have been made with the same degree of care as has been employed upon the more seriously polluted rivers, although, judged solely from the terms of the reference, the application of general remedies is not called for at the present time. These studies, however, have been made to serve a twofold purpose. In the first place, the relation of sewage disposal to water supply on either side of the river is one demanding some definite and immediate local consideration, independent of any international questions involved. These lead necessarily to minimum requirements of treatment and can not reduce the local requirements, which are in general more exacting. In the second place, this river probably will be the first of the remaining streams to fall within the limits of effective dilution, and the studies that have been made will serve to point out the requirements of the future toward which drainage studies and allied problems should be directed. Studies of this character are needed and should be made in the near future in the case of all of the other communities upon the boundary rivers. It is worthy of suggestion that in the interest of economy and uniformity of administration, studies along these lines might well be continued by the International Joint Commission or by the administrative organization appointed to deal with this matter. In this way the problems of the future will be more definitely brought to the notice of these communities and their

general solution will be better correlated along similar lines.

Guiding Principles in Control of Pollution.

The following general principles should guide in the formulation of regulations for the control of pollution in the boundary waters in its international aspects:

1. The boundary waters shall not be polluted on either side to the injury of health or property upon the other.

2. In the case of the boundary rivers the interests of the two countries are so closely bound together as to be mutual and the quality of the streams as a whole shall be considered in determining upon limits of permissible pollution.

3. The limit of permissible bacterial pollution shall be deemed to have been exceeded when the effective dilution as hereinafter defined shall be less than 4 cubic feet per second per capita of contributing population, based upon mean river stages during the season May to September, inclusive.

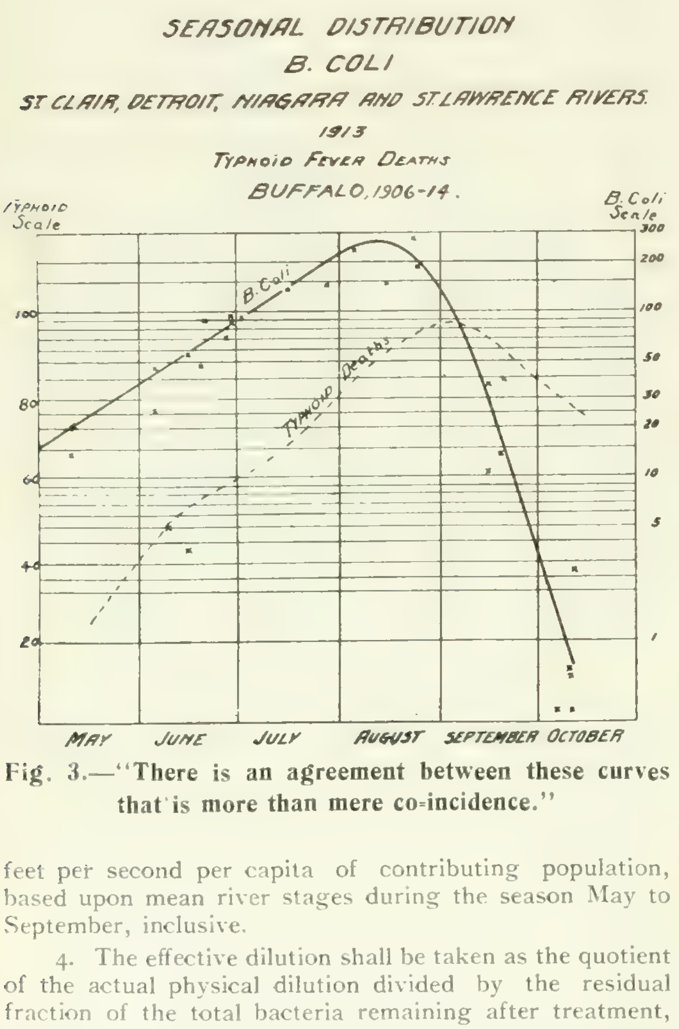


Fig. 3.—"There is an agreement between these curves that is more than mere co-incidence."

4. The effective dilution shall be taken as the quotient of the actual physical dilution divided by the residual fraction of the total bacteria remaining after treatment, provided that in the case of the St. Lawrence and other rivers where the time element is such as to permit some degree of self-purification between points of successive pollution, this factor shall be considered as an element of treatment entering the determination of effective dilution at the lower point.

5. In all cases where the actual stream flow below any one point of pollution is less than 4 cubic feet per second per capita of contributing population, or where the net effect of successive pollution with proper allowance for self-purification in the intermediate stretches exceeds the equivalent of one contributing person per 4 cubic feet per second of stream flow, sewage treatment shall be employed to reduce the net bacterial pollution to a basis of an effective dilution of 4 second-feet per capita, as defined.

6. Sewage treatment, while based primarily upon bacterial pollution, shall also include the removal of suspended solids capable of settling to approximately the same degree as is called for in the case of bacteria; provided that this requirement shall not be extended to an unreasonable degree in the light of good engineering practice; and provided further, that in the case of combined sewer systems, ordinary mineral detritus shall be excluded in computing the degree of removal.

7. In all cases where sewage treatment to a specified degree is demanded, the entire contributory population shall be dealt with upon the same basis of relative improvement required, so that the net residual pollution from each community shall be proportional to its population; provided, however, that where the factor of self-purification is an element in the degree of pollution at any point the population above shall be reduced to equivalent population at that point by the self-purification factor, and the burden of responsibility shall be apportioned in terms of these equivalent populations.

8. Steamboats which pass by waterworks' intakes shall be regarded as being capable of discharging sewage in the near vicinity of those intakes without appreciable dilution. The application of the rule leads in this case to a complete bacterial purification or sterilization before discharge. Equivalent removal of solids capable of settling will not be required in the case of steamboats.

9. No garbage, city waste, offal, or other like material capable of polluting or rendering offensive the waters shall be deposited in the boundary rivers, or in such places as will permit their reaching these rivers.

[Prof. Phelps states that the administrative control of boundary water pollution is obviously a federal rather than a state or provincial matter. It is recommended that the federal health authorities of the United States and Canadian governments would naturally and logically constitute, or nominate, a joint administrative body for the direct enforcement of a continuing policy of stream protection. In the matter of cost of the improvements proposed it is assumed that the burden of responsibility is individual and to be borne equally per capita by all concerned.]

In order to discover how well the train-operating rules and signals were being obeyed on the Pennsylvania Railroad system, considerably more than four million tests and observations, covering the work of both officials and employees, were carried out during last year. The results, which have just been compiled, show that only one error occurred in every 1,110 trials, or that the working in this respect was 99.9 per cent. of absolute perfection. In four classes of tests, including the most important test of obedience to various "stop" signals, no failure on the part of any employee occurred throughout the year. An exceptionally good record was also made in the observance of rules especially intended for the protection of employees. In connection with the moving of trains 68,941 observations were made and 17 errors recorded, while with regard to the safety rules for track workmen the 342,991 tests made showed only 73 cases in which the rules were disregarded in any way. Failures strictly to observe the rules governing watchmen stationed at grade crossings occurred on only eight occasions, though 62,934 observations were made. The attention given to the matter of safety regulations is doubtless largely responsible for the fact that last year was the third in succession in which no passenger has been killed in a train accident on the system east of Pittsburg and Erie. Accidents to employees also continue to show a highly satisfactory diminution in numbers; those occurring last year were 11 per cent. less than in the previous year.

Editorial

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS.

In this issue of *The Canadian Engineer* there appears a review of a most valuable report recently issued by the Dominion Water Powers Branch in connection with the power and storage investigations on the Winnipeg River in the Province of Manitoba, which investigations have been carried on for the last three or four years. It may interest many of our readers to know that these investigations were commenced on the advice of prominent consulting engineers of both the United States and Canada, following a reconnaissance trip down the Winnipeg River, and were made necessary because of the Government wanting a well-defined administrative policy evolved covering the physical features of the use of the various falls of the Winnipeg River for power purposes.

When one considers the great agricultural wealth of a province like Manitoba, but which is more or less without fuel resources, and that water is practically the only natural resource within the province for the development of power, the importance of the facts which are brought out by these lengthy investigations will be realized.

It is interesting to find that the net results of the investigations show that the Winnipeg River power situation is a most promising one from both an engineering and an economic standpoint.

COLLECTING HIGHWAY DATA.

Forms are being sent to many of the city and highway engineers throughout Canada, requesting data concerning the construction and maintenance of pavements. This data will be compiled by a committee of thirteen members of the Canadian Society of Civil Engineers. W. A. McLean, Toronto, is chairman of the committee, and G. C. Parker, secretary of the Department of Public Highways, Parliament Buildings, Toronto, is secretary of the committee.

The object is to get full data concerning the construction of pavements of every kind, and then to keep a record of their serviceability as shown by the subsequent annual reports regarding maintenance, traffic, etc.

In order to take into consideration all conditions of climate and traffic, these forms are being sent to many different towns and cities in every part of the Dominion. As there will be a score or more of different pavements to be reported upon, the work will likely involve considerable detailed clerical effort. If successful, the results will be very instructive and may lead to standard specifications for some types of pavements which will enable the engineer to predict, before the pavement is laid, just how many years it will last under any given condition of traffic.

To be successful, however, it is absolutely necessary that complete, careful and intelligent information be furnished by every man who receives these forms, and *The Canadian Engineer* would urge all engineers who are asked to co-operate in this matter, to do so promptly and fully, in the interest of the advancement of highway engineering.

The questions asked by these forms are published in full upon another page of this issue. Any engineer who does not receive a copy of the official form, and who would like to report from year to year upon any pavement, should correspond with Mr. Parker.

ANOTHER WATER POWERS INVESTIGATION?

Duplication of effort by various government organizations and commissions has frequently resulted in considerable waste of time and money. This overlapping has not been confined to any one political party. It has been more or less prevalent at all times.

With the heavier duties that Canada has undertaken during the past two years, it is important that every possible lesson of efficiency be learned from past mistakes.

Unless *The Canadian Engineer* is misinformed in this matter, the Federal Economic Commission plans to investigate the water powers of the Dominion. Such investigation would seem to be gross waste of effort, unless it is meant to imply that the work that has already been done in that field has not been sufficiently thorough.

Water power investigations have been made by the Dominion Water Powers Branch, and we do not believe that the work of that department has been lacking in any reasonable particular.

Moreover, many of the provincial governments have made considerable headway in similar investigations: Nova Scotia, through the Nova Scotia Water Power Commission; British Columbia, by close co-operation with the Dominion authorities; Ontario, through the Hydro-Electric Power Commission; Quebec, through the Quebec Streams Commission; etc. Besides these, the Commission of Conservation has made various voluminous reports upon the subject; and excellent papers were prepared for the International Engineering Congress at San Francisco last year by various well-known engineers, each one reporting upon the water powers of the province with which he is most familiar.

Does the Federal Economic Commission propose to ignore all this previous work accomplished by experts? If so, why? If not, whom does the commission intend to appoint who is recognized as a hydraulic authority able to review the work previously done, and sufficiently well versed in the theory and practice of hydraulic engineering to be able to reject as invaluable any of the work which these various other bodies have accomplished? If the Federal Economic Commission proposes to delve into engineering investigations of this sort, it will certainly have to add materially to its staff and to its funds.

We hope that our information regarding the commission's plans is incorrect, but anyway we would most respectfully advise the commissioners to reconsider the matter and to devote themselves exclusively to the main purposes for which the commission was created, namely, to handle immigration problems, to increase agricultural production and to improve facilities for marketing farm products.

COAST TO COAST

Quebec, P.Q.—The following gentlemen have been appointed by an order-in-council to form the newly created Road Commission: Mayor Lavigueur, N. Garneau, Mayor [illegible], Mr. Frank Carrel, and ex-Mayor Drouin. It is understood that Mr. Nap. Drouin has been slated for the chairmanship of the commission.

Calgary, Alta.—The largest clean-up campaign in the history of the city was the one recently completed. During the clean-up period 11,509 cubic yards of rubbish was handled. Of this, 8,029 cubic yards was dumped at the city dump and 2,280 was handled by the city incinerator, according to the report of Sanitary Inspector Dunn, made to Commissioner Garden. The whole of the city, from the centre to the extreme outskirts, was covered.

Angus, Ont.—It is the intention of the Militia Department to instal at Camp Borden a complete sewerage system on the water carriage basis. The camp will be supplied with water either from artesian wells or from the Pine River. As the camp will have a summer population of approximately 40,000 soldiers, the problem of installing a complete sewerage and water supply system for what is nearly a city of that size within a period of from four to five weeks is one of most unusual character. T. Aird Murray, M.Can.Soc.C.E., is consulting engineer in connection with this installation.

Ojibway, Ont.—It is [illegible] that construction work is likely to begin soon on the Canadian plant of the United States Steel Corporation. The following statement, regarding its plans in Canada, has been given to *The Canadian Engineer* for publication, by the United States Steel Corporation: "The Canadian Steel Corporation, Limited, which has been organized in the interest of and is controlled by the United States Steel Corporation, has acquired about 1,750 acres of land at Ojibway, Ontario, opposite the city of Detroit, Mich. The property has a frontage of about a mile and a half on the Detroit River. On this site it is hoped to construct a modern steel plant. The plans for the scope of the plant have not yet been fully developed. The plant should include blast furnaces, open-hearth steel works, rail mill, wire mill, structural and bar mills, sheet mill and perhaps some other mills, together with all necessary plant auxiliaries such as docks, by-product coke plant, power stations, pumping plant, machine shops, foundry, etc. A portion of the property acquired is intended for a townsite and it is planned to improve and develop the same by platting and constructing streets, laying water mains, installing sewerage system and a gas and lighting system; also to construct necessary dwellings for employees and others. A considerable amount of preliminary development work has already been done and during the balance of the present year initial construction work will be prosecuted. The officers of the Canadian Steel Corporation, Limited, are: Elbert H. Gary, president; Ward B. Perley, vice-president; Richard Trimble, treasurer; W. J. Filbert, secretary. Vice-President Perley will be immediately in charge of the active construction work and his office will be at Ojibway, Ontario." It is reported that the contract has been awarded to the Williamson Construction Company, of Walkerville, for fitting up the Lloyd House in Ojibway as an office headquarters for the company. Some extensive building is contemplated and a substantial sum has been appropriated.

PERSONAL.

R. M. HANNAFORD, assistant chief engineer of the Montreal Tramways Company, has been elected president of the Canadian Railway Club.

R. V. NICHOLSON, heretofore bridge and building master of the Canadian Pacific Railway at Schreiber, Ont., has been appointed bridge and building master at Ottawa.

CAPT. BARRY has been appointed engineer in charge of the waterworks and sewerage system for the new military camp at Angus, Ont.

T. AIRD MURRAY, M.Can.Soc.C.E., has been appointed consulting engineer in connection with the waterworks and sewerage system for Camp Borden, near Angus, Ont.

A. C. VOLKMAR, forester of the Riordan Paper Company, St. Jovite, Quebec, has been elected an associate member of the Canadian Society of Forest Engineers.

CHARLES L. D. CONKLIN, until recently president of the Digger Machinery Co., Inc., has severed his connection with that concern and is now with the John F. Allen Co., New York, as superintendent of their contractors' machinery department.

OBITUARY.

ELMER LAWRENCE CORTHELL, Dr.Sc., president of the American Society of Civil Engineers, died May 16th. In the passing of Dr. Corthell the engineering profession has suffered a real loss. He was a man who had attained to unusual heights in that profession. His fame as an engineer was almost world-wide; his reputation as a consulting engineer was national and international. He was born at South Abingdon, Mass., in 1840. While attending Brown University the Civil War broke out. He immediately enlisted and after serving four and a quarter years with the army re-entered Brown University and received the degrees of B.A. and M.A. From his alma mater and in recognition of his attainments as an engineer he received the degree of Doctor of Science. During his life he was connected with some very large and important engineering enterprises. Among these might be mentioned the following: The improvement of the harbor at Tampico, Mexico; the National Railroad of Tehuantepec, the completion of which was entrusted to him by the Mexican government; the Boston, Cape Cod & New York ship canal; the river and harbor improvements in Argentine, and many other national and international projects. Out of respect to the memory of Dr. Corthell the regular semi-monthly meeting of the American Society of Civil Engineers, which was held May 17th, was immediately adjourned after the announcement of his death had been received.

CALGARY ENGINEERS ENLIST.

The following members of the Calgary Branch of the Canadian Society of Civil Engineers have enlisted for active service:—

Members.—H. B. Muckleston, F. R. Burfield, Col. Paul Weatherbae.

Associate Members.—P. J. Jennings, H. R. Carscallen, F. S. Dyke, G. R. Elliott, J. A. Symes.

Juniors.—R. L. H. Goodday, J. H. Jones.

Students.—J. B. McLean.

Associate of Branch.—G. H. Whyte.

Volume 30. Toronto, June 8, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

SOME ASPECTS OF CHLORINATION*

IN VIEW OF THE INCREASING USE OF LIQUID CHLORINE OR HYPOCHLORITE FOR THE STERILIZATION OF WATER, THE OBSERVATIONS OF THE AUTHOR OF THIS PAPER SHOULD BE OF CONSIDERABLE INTEREST TO WATERWORKS ENGINEERS.

By JOSEPH RACE,
City Bacteriologist, Ottawa, Canada.

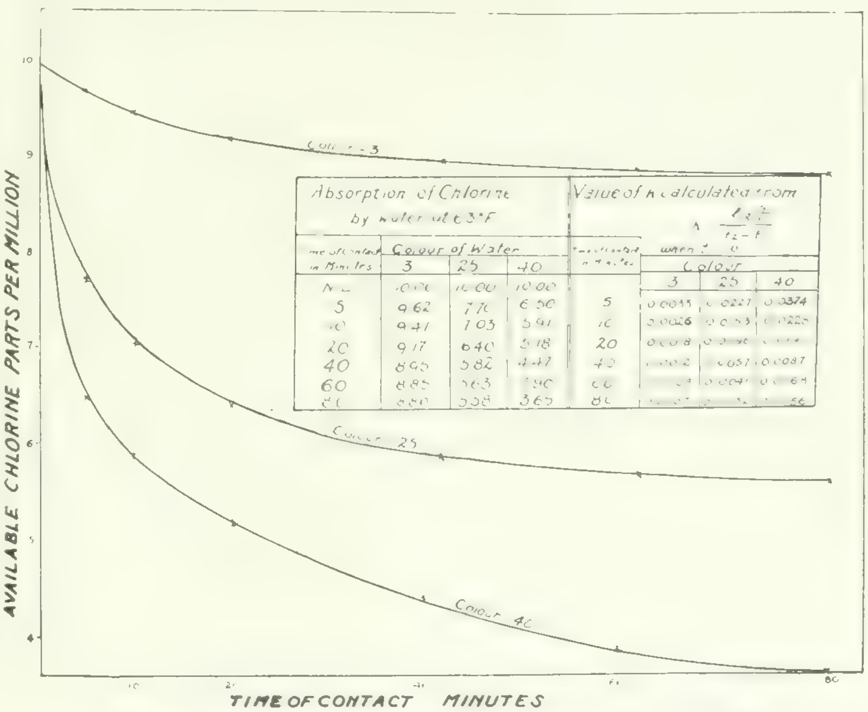
ALTHOUGH the treatment of water by chlorine or hypochlorite has been very extensively practised for several years it is a regrettable fact that comparatively few investigations have been made into this process with a view to elucidating the basic principles and the modifications required to meet various conditions.

When chlorination was first introduced for the sterilization of water and sewage, all that was required was the addition of the hypochlorite; after this the process was supposed to take care of itself. Now we realize that to obtain the best results the process requires careful supervision and close attention to certain points. It is the purpose of the writer to draw attention to some of these details in this paper.

Mechanical Admixture.—Due attention has not always been given to this phase of the chlorination problem because of the prevalent opinion that the all-important point was contact period. The writer has previously recorded (Journ. Soc. Chem. Ind., 1912, 31, 611-616, and 1915, 34, 931-934) experiments made for the purpose of comparing the importance of these two factors. In 1914, a sedimentation basin was placed in operation at the mouth of the Ottawa intake pipe and during July the hypochlorite solution was added at the entrance to this basin. The method of addition was by means of a perforated pipe which stretched across the entrance to the basin and the bleach solution and water were there mixed as thoroughly as was possible without having recourse to mechanical methods. The basin was baffled and had a normal capacity equal to approximately two hours' consumption (1.7 million Imp. gallons). The results obtained were as follows:—

Available Chlorine = 1.88 p.p.m. Bacteria per c.c.

	Agar 3 days at 20°C.	Agar 1 day at 37°C.	B Coli Index per c.c
Raw water	41[illegible]	1[illegible]4	[illegible]
Treated water	49	2[illegible]	0.036
Percentage purification..	88.2	75[illegible]	87.500



EFFECT OF COLOUR ON ABSORPTION OF CHLORINE BY WATER
Diagram 1.

During August the connection at the entrance to the basin was closed and the bleach liquor added directly to the suctions of the low-lift pumps, which take water from the sedimentation basin and place it in the intake pipe under a small positive pressure until it reaches the high-lift pumps. During both months the samples of treated water were taken from the well which receives the mixed discharges of the low-lift pumps. These results, which are the averages of daily analyses, show that the efficient mechanical admixture produced much superior results with a smaller consumption of chlorine. The results for August were:—

Available Chlorine = 1.55 p.p.m. Bacteria per c.c.

	Agar 3 days at 20°C.	Agar 1 day at 37°C.	B. Coli Index per c.c
Raw water	44[illegible]	[illegible]	[illegible]
Treated water	26	[illegible]	0.005
Percentage purification..	91.9	88.0	99.200

Color.—The effect of color, as is well known, is to reduce the efficiency of chlorination and to necessitate the use of a much larger dose. This is well exemplified in the following table, which gives the results of chlorination experiments on B. Coli seeded into water. Water "B" was

*Read before the American Waterworks Association, June 8th, 1916.

the raw Ottawa River water containing 40 parts per million of color and water "A," with a color of 3 parts per million was produced from "B" by precipitating with sulphate of alumina and subsequently filtering. The B. Coli count was made by platting out 10 cubic centimeters of water in neutral red bile salt agar and counting the typical red colonies. Counts were made after 24, 48 and 72 hours, but in this table only the 24-hour count is recorded. The counts at later periods were made to determine whether the organisms were actually killed or the reproductive capacity merely delayed, as was observed on a former occasion. (Journ. Soc. Chem. Ind., July, 1912.) In none of the experiments was any evidence obtained of any revival of the organisms.

TABLE I.

Colonies Per 10 c.cms. of Water. Temp. = 63° F.

Contact Period	Water "A" Color 3 Available Chlorine p.p.m. 0.2	Water "B" Color 40 Available Chlorine p.p.m. 0.2	0.4	0.5
Nil	104	104	104	104
5 minutes	121	[illegible]	120	44
1 hour	7	95	20	1
5 hours	[illegible]	4	0	0
24 hours	0	1	1	0
48 hours	0	0	0	0

To obtain the same result with about one hour's contact at 63° F. it is necessary to use about two and one-half times as much chlorine with a water of color 40 as with one practically free from color. Somewhat similar results have been obtained at Montreal by Harrington (Journ. Am. Waterworks Assoc. Vol. 3, 438). For the greater part of the year St. Lawrence water free from color is obtained at the inlet to the Montreal intake pipe and only requires approximately 0.3 parts per million of available chlorine for satisfactory treatment. During the spring floods the currents are altered and the Ottawa River water is obtained. This requires as much as 1.5 p.p.m. of chlorine but a portion of this high dose is necessitated by the increase of turbidity. During the flood period the color is somewhat reduced but its effect in the chlorination efficiency is more than counterbalanced by the increase in turbidity.

The effect of color upon the absorption of chlorine, in the form of hypochlorite, by water, is well shown in Diagram 1. The absorption takes the form of a monomolecular reaction, the mathematical expression of this law being $\frac{dN}{dt} = KN$ where N is the concentration of the available chlorine in parts per million. Integrating between t_1 and t_2 we get the formula

$$K = \frac{\log. \frac{N_1}{N_2}}{t_2 - t_1}$$

If the compound absorbing the chlorine were simple in character, the value of K found would be constant in each experiment. Instead of that, we find a constantly diminishing quantity which is explained by the fact that the compound acted upon is not simple but a mixture of complex molecules having different affinities for oxygen.

Temperature.—The effect of temperature on a culture of B. Coli in unsterilized water (color 40) is well illustrated in the two following tables.

TABLE II.—EFFECT OF TEMPERATURE.

Colonies Per 10 c.cms. of Water. Available Chlorine 0.4 p.p.m.

Contact Period.	Temperature Degrees Fahrenheit 36.	70.	98.
Nil	424	424	424
5 minutes	[illegible]	280	[illegible]
1.5 hours	148	70	12
4.5 hours	8	14	3
24 hours	2	6	0
48 hours	2	0	0

TABLE III.

Colonies Per 10 c.cms. of Water. Available Chlorine 0.2 p.p.m.

Contact Period.	Temperature Degrees Fahrenheit 36.	70.	98
Nil	240	240	240
5 minutes	240	250	235
1 hour	245	235	195
4 hours	215	190	170
24 hours	143	130	115
48 hours	130	59	19
72 hours	..	28	..
96 hours		16	..
120 hours		6	

In the 70° F. experiment, the sample, after 3, 4 and 5 days' contact, was inoculated into lactose bile and lactose broth with the following results:—

Contact Period.	Lactose Bile.	Lactose Broth.	B. Coli Per 10 c.c. Most probable number. Lactose Bile.	Lactose Broth.	Colonies per 10 c.c. on Rebipelagar.
72 hours	2 5	5 5	5	20	28
96 hours	0 5	4 5	1	16	16
120 hours	0 5	2 5	1	5	6

When these results are calculated to the most probable numbers by McCrady's method (Journ. Inf. Dis., 1915, 17, 183-212) some interesting comparisons are obtained. The lactose broth and rebipelagar plates are in close agreement but yield results very much higher than the lactose bile. If lactose bile only takes account of virile organisms it must be assumed that the majority of the B. Coli remaining after 72 hours' contact, are attenuated. This dictum would appear to be somewhat arbitrary and empirical.

The effect of temperature upon the absorption of the available chlorine is shown in Diagram 2.

Aftergrowths.—In connection with chlorination many well-authenticated reports have been made that after the preliminary germicidal action has subsided a second phase occurs in which there is an accelerated growth of organisms. This is usually known as aftergrowth. When there is only a short contact period between chlorination and consumption, the reaction does not proceed beyond the first phase, but when the treated water is stored in service reservoirs the second phase may ensue and is usually ascribed to a change in pabulum effected by the action of the chlorine or oxygen on the organic matter. Regarding the nature of this aftergrowth there has been considerable difference of opinion; some hold that it is the result of the multiplication of a resistant minority of practically all the species present in the untreated water; others, that it is partially due to the bacteria being merely "slugged" or "doped," *i.e.*, in a state of suspended animation, and afterwards resuming their anabolic functions, whilst others believe that with the proper dose of chlorine only spore-forming organisms escape destruction and that the aftergrowth is the result of these cells again becoming vegetative. The aftergrowths obtained under the usual working conditions vary according to the dosage of chlorine employed and none of the above hypotheses alone provides an adequate explanation. When the dosage is small a small number of active organisms in addition to spore-bearers will escape destruction, and others, as was shown by the writer in a previous paper (Journ. Soc. Chem. Ind., 1912, 31, pp. 611-616), will suffer a reduction of reproductive capacity. The flora of the aftergrowth in this case will only differ from the original flora by the elimination of species that are very susceptible to chlorine As the dose is increased these two factors become relatively less important until a stage is reached when only the most resistant cells, the spores, are left; the resultant aftergrowth must necessarily be entirely composed of

spore-forming organisms. Chlorination operators do not usually use a dose that would eliminate all but spore-bearers and it therefore becomes essential that we should know whether the aftergrowth has any sanitary significance. Concerning the secondary development of B. Coli, the usual index of pollution, there is but very meagre information. H. E. Jordon (Eng. Rec. 1915, May 17) reported that of 201 samples, 21 gave a positive B. Coli reaction immediately after treatment, 39 after 24 hours' standing and 42 after 48 hours. These increases were confined to the warm months, the cold months actually showing a decrease. The following figures, taken from the writer's routine tests for 1913 and 1914, show a similar tendency, but an analysis of the results by months did not show that this was confined to the summer months.

The sequence of the results from left to right in the following table is in the same order as the contact period, and each percentage represents the average of approximately 290 samples.

Percentage of Samples Showing B. Coli in 10 c.cms.

	1.	2.	3.	4.	5.
1913	15.2	14.4	16.3	16.8	26.8
1914	7.0	5.7	6.0	....	11.[illegible]

At station 2 the germicidal action was evidently still proceeding, but at station 5, representing an outlying section of the city, the increase is marked.

During 1915 and 1916 the writer attempted to duplicate these results under laboratory conditions and entirely failed. Usually these experiments, which were made with the same materials as were in use at the city plant, but in glass containers, were only carried to 48 hours' contact, as this would be the extreme limit found in practice; one, however, was prolonged to 5 days. Many experiments of this nature were made with varying conditions, but as the results are all similar there is nothing to be gained by adding to those given above in tables 1, 2 and 3. In every case there is a persistent diminution in the number of B. Coli organisms found with increase of contact period. Determination of the bacterial count on nutrient agar showed in several cases that the aftergrowth had commenced and in some instances there was evidence that the second cycle was partially complete, *i.e.*, the number had reached a maximum and then commenced to decline. The time required for the completion of the two cycles, comprising the first reduction caused by the chlorine, the increase or aftergrowth and the final reduction due to lack of suitable food material, is dependent upon various factors of which the dosage and temperature are the most important. With a small dosage the germicidal period is short and the second phase quickly reached; with large doses the second phase is not reached within 48 hours. Low temperatures reduce the velocity of the germicidal action but extend the period over which it is effective. The higher the temperature the quicker is the action and the development of the aftergrowth. These statements refer only to the total bacteria as found by development on nutrient agar. The B. Coli did not act in this way and persistently diminished in every case. If B. Typhosus acts in a similar manner to B. Coli, the laboratory experiments show that aftergrowths are of no sanitary significance and can be safely ignored, but as the results obtained in actual practice are apparently contradictory the matter should be regarded as *sub judice* until more definite evidence is available. Perhaps the remarkable photochemical properties of chlorine are concerned in this matter.

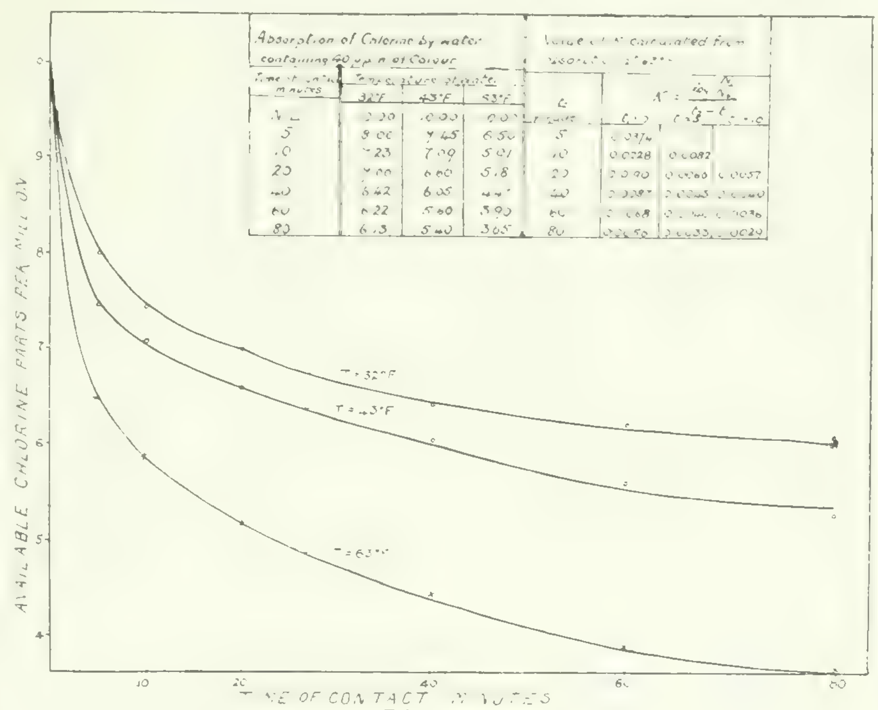


Diagram 2.

Corrosion.—Numerous complaints regarding corrosion of piping systems in Ottawa led to the routine determination of free carbonic acid in the raw and treated waters. During a period of excessive turbidity and pollution a very heavy dose of chlorine was used and an increase in the free carbonic acid resulted. During the past 18 months the average results show a decrease, so that there could scarcely be an increased corrosive action due to carbonic acid.

If the treatment is considered according to the electrolytic theory, a slight increase in corrosion might be expected due to an increased electrical conductivity. The conductivities of various chlorinated mixtures were therefore determined with the results as shown in Diagram 3.

With the usual dosages of chlorine it is inconceivable that the increased electrical conductivity has any practical significance at ordinary temperatures. At temperatures approaching the boiling point of water the percentage increase in conductivity would be somewhat greater and may possibly assume practical importance.

Surviving Types of B. Coli.—Several experiments were made with a view to ascertaining whether the B. Coli found after chlorination were more resistant to chlorine than the original culture. The colonies surviving after treatment with comparatively large doses were fished into lactose broth and this culture used for a second chlorination. The surviving organisms were again fished and the process repeated several times. The velocity of the chlorination reaction varied somewhat, but not always in the same direction and the variations were not greater than was found in duplicate experiments with the original culture. No evidence was obtained that the surviving organisms were in any way more resistant to chlorine than the original culture. It should be remembered, how-

ever, that the surviving types were cultivated twice on media free from chlorine before being again subjected to chlorination. A number of the colonies surviving several chlorinations were cultivated in lactose broth and the acidity determined quantitatively. All the cultures produced less acid than the original culture and the average was materially less than the original cultivated under the same conditions. This points to a diminution in the biochemical activity.

A point of perhaps more scientific interest than practical utility is the relative proportion of the various types of B. Coli found before and after treatment with chlorine. The writer, in 1914 commenced the analysis of the various types, using the division of the American

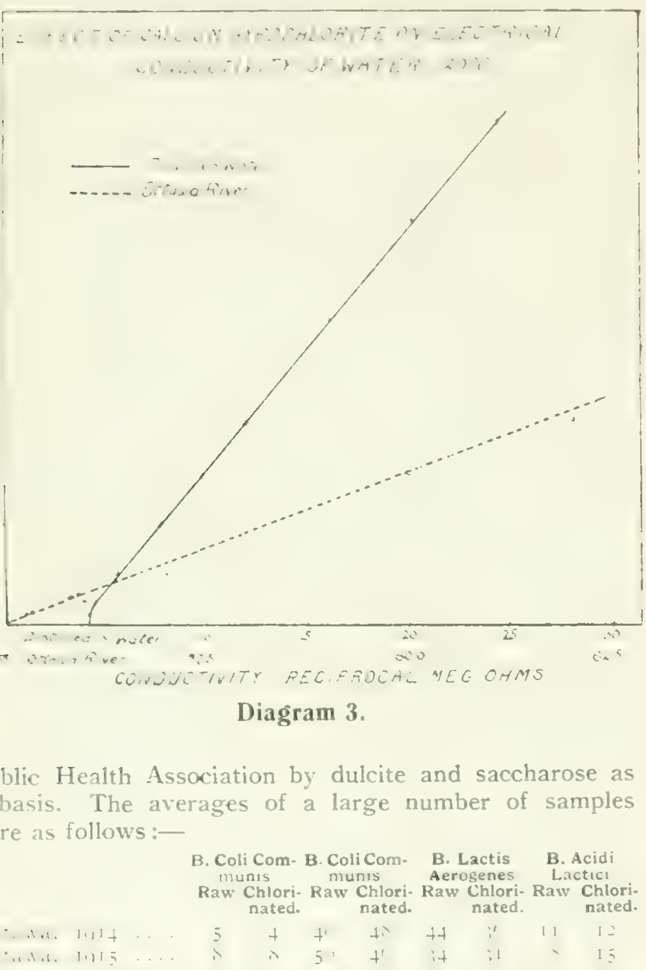


Diagram 3.

Public Health Association by dulcite and saccharose as a basis. The averages of a large number of samples were as follows:—

	B. Coli Communis Raw	B. Coli Communis Chlorinated.	B. Coli Communis Raw	B. Coli Communis Chlorinated.	B. Lactis Aerogenes Raw	B. Lactis Aerogenes Chlorinated.	B. Acidi Lactici Raw	B. Acidi Lactici Chlorinated.
Ottawa, 1914	5	4	40	48	44	36	11	12
Ottawa, 1915	8	8	50	[illegible]	34	31	8	15
*Baltimore, 1913 ..	11	14	33	25	35	31	21	30

*Thomas and Sandman, J. Ind. and Eng. Chem. 1914. [illegible]

Although there is a slight difference in the relative proportions of the types found at Ottawa and Baltimore, both sets of results show definitely that there is no difference in the resistance of the various types to chlorine.

The net earnings of the Manitoba Government telephones for the five months ended April 30, totalled $202,571.41, according to the condensed earnings report and balance sheet recently issued by the public utilities commissioner.

Announcement has been made to the effect that the British Columbia Government will introduce legislation to provide $200,000 for the purpose of opening up roads and trails to places in the mountains where there are "pioneer" prospects

AGGREGATE STUDIES AT THE WINNIPEG AQUEDUCT.*

By James H. Fuertes.

THE Greater Winnipeg Water District is now building works for securing by gravity about 100,000,000 U.S. gallons of water per day from the Lake of the Woods, which lies about 100 miles east of, and some 300 ft. higher in elevation than, the city of Winnipeg.

Under the terms of the contract the District agrees to deliver the sand and gravel to the contractor at a stated price per cubic yard. Actually the District is shipping these mixed, but billed as sand and gravel in accordance with the ratios of the volumes that the sand and gravel would make separately, these having been determined from an extended laboratory study of the materials. It would be impossible, within space limits, to do justice to this phase of the subject. Owing to the percentage of sand in the gravel pit it is necessary to dig considerably more material than can be made into concrete aggregate. Thus in August there were excavated at the pit approximately 24,000 cu. yds. of material, of which 6,000 cu. yds. was stripping and 18,000 cu. yds. of sand and gravel; of the 18,000 cu. yds., 13,000 cu. yds. were concrete aggregate, a large proportion of which contained 50% of sand, and 5,000 cu. yds. was ballast and foundation fill material. It is desirable that the percentage of sand in the concrete aggregate should not exceed 35% of the whole in order to have an economical concrete. With a larger percentage of sand the amount of cement required to make a watertight concrete has to be increased. With a proper proportioning of the materials, particularly of the sand, by using certain percentages of sand passing the 100-mesh screen, it was possible to make concrete that was watertight under 80 lbs. pressure per square inch, with about 1 Canadian barrel (350 lbs.) of cement per cubic yard of concrete.

From a long series of samples of the materials from test pits in the gravel deposits at the pit it was found that the average run of the better samples contained about 3.3% of fine sand passing the 100-mesh sieve, the percentage of sand to total aggregate varying between quite wide limits. It was also recognized that it would be desirable from the point of view of economical development to use as large a proportion of sand in the final aggregate as safety would permit, bearing in mind that the amount of cement required to make tight concrete should be kept in a minimum. The allowable percentage of sand was finally fixed at 35% of the total aggregate, by weight, and the series of tests for permeability is based largely on this percentage, although a few tests were made with larger and smaller percentages.

Fig. 1, made up from the data obtained in the tests, shows the percentages of fine sand (passing the 100-mesh sieve) required to make watertight concrete with 10% of cement (370 lbs. of cement per cubic yard of set concrete) when the sand is 35% by weight of the total aggregate, with varying percentages of intermediate and coarse materials.

Using 12% cement, with sand having 3.3% passing the 100-mesh sieve, watertight concrete could be made with sand varying from 23% to 43% of total aggregate and with intermediate and coarse, in equal proportions varying from 77% to 57% respectively, or, if coarse were

*Extract from a paper read before the Western Society of Engineers.

absent, with sand at 35% and intermediate at 65%. Fairly good results were obtained with 12% cement, even with 49% sand and 51% intermediate, but this concrete slowly absorbed considerable water, showing a fairly large percentage of very small voids.

In order to be on the side of safety, in starting a new plant, the minimum quantity of cement that has been used when aggregate containing 35% sand has been shipped out, has been 12%, corresponding to about 1.27 bbls. (Canadian) to the cubic yard. The first cut in the gravel pit, arranged for a convenient lay-out for operating conditions, has taken the excavating machines into a part of the deposits running high in sand, and in order to keep the total sand in the finished aggregate down to 35% required a considerable wastage of sand after screening, which cuts down the net output and increases the amount of material to be handled. As the demands of the contractors have taxed the plant heavily, due to a number of causes, among which were delays due to breaks in machinery, lack of storage for the mixed aggregate, shortage of cars at times when the haul was long, or when large amounts of foundation fill materials were being shipped, it was found necessary, at times, to ship out material containing 50% sand, and in some cases, pit-run material. In such cases the cement has been increased to about 15% or 1.7 bbls. (Canadian) per cubic yard. This policy is very expensive, however, as it increases the cost of concrete to the District by about $1 per cubic yard net, over the cost of concrete made with an aggregate containing 35% of sand. As the estimated volume of concrete in the whole aqueduct is about 330,000 cu. yds., the District is, this winter, planning to open another pit, equipped somewhat differently, near the eastern end of the line, to relieve the pressure on the existing plant both by furnishing more aggregate and by shortening the haul, thus getting better efficiency out of the transportation equipment.

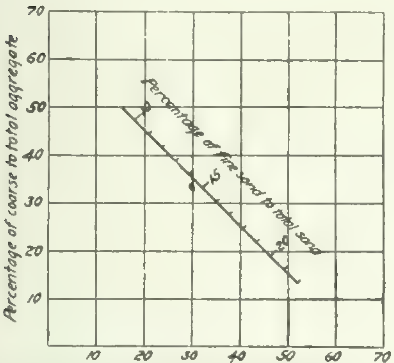


Fig. 1. Percentage of intermediate to total aggregate

The mixed sand and gravel is loaded into 20-yd. air-dump cars at the screening plant, hauled to the contractor's platforms and dumped. The cars are loaded, as nearly as possible to a loose measurement of 23 cu. yds., then scaled, and billed out to the nearest even yard below the scaling. Of 110 cars loaded and billed out, in one test, 15 contained by scaling 22 cu. yds., 75 contained 23 cu. yds., 19 contained 24 cu. yds., and one contained 25 cu. yds. The total measured yardage in the cars was 2583.1 cu. yds., and the total billing was 2,536 cu. yds., a difference of 47.1 cu. yds. or 1.85% more material shipped than billed for, due to taking the nearest even yard below the scaling; or, roughly, the deliveries averaged nearly ½ yd. per car in excess of the billing. A further excess of deliveries over billing, in cars levelled off for measurement, also arises from the mechanical effect of the consolidation of the material in the cars of measured aggregate by the men when levelling off the cars. For example, 17 cars were measured at the plant, then levelled off and trimmed. Before levelling, the measured contents was 392 cu. yds. and after levelling off 380.6 cu. yds., a difference of 11.4 cu. yds., of 3% shrinkage due to consolidation by the men's feet.

The relative weights of the aggregate per cubic foot under different conditions as to moisture and compacting are shown in the following table, the sand in the moist aggregate being about 37% by weight:—

Weight per cubic foot loose and moist	114 lbs.
Weight per cubic foot shaken and moist	122 lbs.
Weight per cubic foot tamped and moist	132.5 lbs.
Weight per cubic foot loose and dry	125.0 lbs.

from which it will be seen that the percentage shrinkage from the loose and moist condition to loose and dry was 9.65% and to shaken and moist 7% and to tamped and moist 15.8%.

The shrinkage in volume during transportation from the pit at mile 30.8 to different points along the line is shown in Table I.

In order to determine the ratio of aggregate billed out from the plant to the yardage of concrete put in place, measurements of both aggregate yardage and yardage of concrete laid were kept by all the division engineers for a week. Owing to inaccuracies in trimming the bottoms of trenches and to the small excess quantities of concrete in the arch sections, due to hand finishing the tops a little higher than the theoretical lines, the payment concrete

Table I.

Shrinkage in yardage of aggregate during shipment from mile 30.8 to different points along aqueduct line.

(Aggregate 50% sand; 4 cu. ft. cement to 16 cu. ft. aggregate = about 1.7 bbls. cement per cubic yard of concrete.

Date.	Mile at which sand was delivered.	Cu. yds. billed.	Cu. yds. measured at pit.	Cu. yds. at plant after levelling and trimming.	Cu. yds. as measured at point of delivery.	Ratio of billed to cu. yds. measured at delivery.	Ratio of cu. yds. measured to cu. yds. delivered and measured there.
August 26	40	23	23.6	22.2	21.8	1.055	1.08
August 26	43	46	46.6	44.2	43.3	1.060	1.08
August 27	51	46	46.2	46.2	42.2	1.090	1.09
August 27	57	69	69.6	67.8	66.6	1.045	1.055
August 27	65	69	[1]68.1	68.1	64.1	1.075	1.06
August 27	71	45	45.4	44.3	41.5	1.085	1.095
August 27	77	45	45.4	44.8	40.8	1.100	1.110
August 27	85	46	45.8	45.0	42.4	[2]1.085	1.08

[1]Car levelled up for measurement at plant and settled in process of levelling.

[2]Side doors of car raised in transit about 2 inches and some material leaked out.

averages less than the actual quantities placed. These ratios are shown to be about as follows:

Total cu. yds. of aggregate billed.	= 3,633.2
Total cu. yds. of concrete laid ...	= 3,422.7
Excess of aggregate over total concrete	210.5 = 6 %
Total cu. yds. of aggregate billed.	= 3,633.2
Total cu. yds. of payment concrete	= 3,310.7
Excess of aggregate over payment concrete	322.5 = 10%
Yardage of total concrete	= 3,422.7
Yardage of payment concrete	= 3,310.7
Yardage of excess concrete	112.0 = 3.4%

Costs of Preparing Aggregate.—The average cost per cubic yard of the aggregate, for preparation exclusive of overhead charges, and transportation to the contractor's platforms has been as follows:

Excavation	$0.118
Hauling to plant	.031
Screening and crushing	.139
Loading	.061
Repairs to plant	.019
Repairs to cars, crane and dinkey	.011
Office	.005
Fuel	.123
Total	$0.507

It is expected that this cost will be materially reduced in the coming season.

ANNUAL REPORT ON HIGHWAY IMPROVEMENT IN ONTARIO.

According to the annual report of the Department of Public Highways of Ontario, which has just been received, investigation shows that there are in the province approximately 55,000 miles of roads. About 20,000 miles are well graded earth roads; about 3,000 miles are surfaced with broken stone; and about 19,000 miles are surfaced with gravel. Many of the gravel roads are of inferior construction; nevertheless, the proportion of surfaced roads is very creditable to the municipal organization of the province. Unfortunately, the improvement is not uniform, and the gravelled roads are largely confined to those areas in which gravel has been plentiful; while other districts are devoid of surface improvement other than grading and drainage.

The mileage of surfaced roads is encouraging, however, in that while many may be in a neglected state, or of inferior construction, they would more readily and cheaply respond to the systematic attention which it is the desire of Mr. McLean to encourage. The building of important market roads under county systems will be of more extended benefit by reason of even moderate improvement of the local feeders; while the development of a few roads of greater commercial importance between cities can be made to join up the entire system of roads throughout the province in a most favorable manner.

The report, which contains 226 pages, is filled with data of real value to all highway engineers and contractors. Under the heading "General Features of County Road Systems," it gives briefly the features of the system as organized under the Highway Improvement Act. We reprint herewith extracts from this section of the report:

One of the first duties of a county council, when a county road system has been established under the Highway Improvement Act, is to select a road superintendent. The work is carried on by the road superintendent, under the direction of the council and the road committee of the council. Too much care cannot be taken by the council in the selection of the superintendent. His qualification for the work, and close application to its management, more than any other factor, will determine the degree of success attained. Good business management, with thoroughly practical ideas and methods, are essential. The superintendent is not required by the Act to be an engineer; but, if he is not such, occasional engineering services will be required, especially in bridge construction and details of grading. The cost of management is not great, and, compared with ordinary township methods, is one of the most profitable items of expenditure. Experienced supervision and skilled workmen are gradually trained—largely the secret of good roads wherever they are found.

Cost of County Roads.—The roads commonly built under county road systems are not necessarily expensive. They are usually gravel roads, or broken-stone roads, well graded and drained—such as serve the needs of farm traffic. Preferably material of the locality, gravel or broken stone, is used. If there is no local material, and it has to be brought in by rail, the cost is greater—but is shared by the province.

A number of districts in Ontario, such as portions of York, Peel, Halton, Welland, Essex and Kent, have no local material for road-making. In such cases an entirely new road must be built, often on a clay subsoil, and freight rates on stone must be added—all tending to higher cost, and amounting to from $4,000 to $8,000 per mile.

In other districts, however, such as Frontenac, Lanark or Hastings, there is an abundant supply of stone on or close to the road, and frequently the task is one of regarding and putting a surface over an old stone or macadam road. In such cases, a cost of $2,500 or $3,500 per mile is an ordinary expenditure.

Certain districts, on the other hand, have an abundant supply of gravel. Many of the roads have been gravelled from time to time and a good foundation has been made. In such cases, the work usually consists of removing sod shoulders, improving the drainage, and adding a new surface of gravel—costing from $1,000 to $2,000 per mile for substantial work suited to local traffic.

A standard form of construction consists of an earth grade, twenty-four feet between shoulders, outside of which are the open drains. In the centre of the grade is placed, for a "single track" road, gravel or stone to a width of ten feet, and a depth varying from six to twelve inches, according to the traffic, subsoil and existing foundation. Good grading and drainage are of first importance. The road should be rolled with a ten-ton steam roller to complete for traffic. If the road is on an important line of through traffic, or adjacent to a city, the earth grade should be twenty-seven feet wide instead of twenty-four, and provision made for a "double-track" of gravel or stone, eighteen feet wide. This, however, is rarely necessary. A single track of metal nine or ten feet wide may first be laid, and later widened to eighteen feet as traffic increases.

Duties of Patrolman.—The patrolman's primary duty is to keep the travelled surface in good condition, but there are other duties for which he should be responsible. His chief duties should be: (1) To repair the road surface; (2) to rake off loose stones and gravel; (3) to clean out ditches and their outlets; (4) to keep culverts free from obstruction; (5) to cut and burn weeds; (6) to repair guard rails; (7) to periodically inspect bridges and cul-

verts, and immediately report to the county road superintendent any defects which he himself cannot remedy.

The employment of men in pairs, with a single horse and light wagon, is frequently to be recommended. Two men working together can very often make more than twice the progress, and at considerably less than twice the cost of one man and horse, while there is a tendency to greater contentment and efficiency produced by companionship.

To make a success of patrol work the men must be selected and adapted to the work. At least one man (who will act as foreman) must be able to think for himself, as on him will rest the responsibility of seeing that both are kept employed, and that all labor is put to the best use. It is possible on work of this kind to "fritter away" a lot of time and still appear busy; therefore, the foreman should be able to distinguish between necessary and unnecessary work. The men should be assured of permanent employment, so long as their services prove satisfactory. In patrol work, as in other branches of road construction, increased experience means increased efficiency and greater value. By knowing that their work will last as long as they desire it and prove themselves capable, the men will be induced to take a greater interest in it than if they know it to be only temporary.

The work, as previously stated, is influenced by so many variables as to make a close estimate impossible, but to give an idea of what may be expected, it may be stated that two men with single horse and wagon, commencing on a properly constructed road in good condition, and working full time, should be able to patrol sections about as follows:—

1. Waterbound macadam road: (*a*) Ordinary county roads, light to moderate traffic, 12 to 15 miles; (*b*) more heavily travelled county roads, 8 to 12 miles; (*c*) county roads approaching large towns and small cities, 5 to 8 miles; (*d*) county roads in the vicinity of large cities, and heavily travelled interurban roads, 2 to 5 miles.

2. Bituminous macadam, or waterbound macadam with bituminous surface: (*a*) Lightly travelled county roads, 15 to 20 miles; (*b*) moderately travelled county roads, 8 to 15 miles; (*c*) roads approaching small cities, 5 to 10 miles; (*d*) roads approaching large cities and heavily travelled interurban roads, 3 to 6 miles.

Each man should be equipped with the following tools, which should always be carried on the wagon: Square-nosed shovel, round-nosed shovel, pick, rake, tamping iron, coarse broom, scythe.

The wagon should have a specially constructed box divided into compartments for stone, screenings and tools. In the case of repairs to bituminous-surfaced roads, the compartments will be used for stone chips, tools, and fuel for the heating kettle.

The cost of operations will include the wages of the men and cost of materials used. These cannot be definitely stated, and the amount of stone used for repairing may be expected to vary from 10 cubic yards to 100 cubic yards per mile per annum. The annual cost of repairs, in general, may be expected to range from 3 per cent. to 6 per cent. of the original cost of the roads.

It is not to be expected that patrol work will eliminate the necessity for periodic resurfacing, but it will postpone it for many years. Modern practice is to allow the road surface to wear down a certain amount and then renew it, the patrol work being for the purpose of arresting undue wear in any one place and to correct ruts or depressions in their incipient stages. In the case of bituminous-surfaced roads, if the base has been properly constructed, and the surface systematically maintained, there should be little necessity for work, as far as the travelled portion of the road is concerned, other than the prompt repair of spots where the bituminous coat has worn through.

Maintenance and Repair.—The distinction between the meaning of repair and of maintenance should be well understood in any examination of the comparative costs of various types of road for a given term of years.

"Repair" applies only to the patching of roads; the filling of holes and of wheel tracks. In the case of a brick pavement it may mean the replacing of a few bricks here and there or the restoration of a yielding foundation. In the case of a concrete road it would apply only to the patching of holes and joints or the clearing of ditches, culverts and drains.

While "repair" in all cases implies only necessary patching to keep the surface of the road smooth, the term "maintenance," on the other hand, will include "repair" and also the additional expenditure necessary to restore the road from time to time to its original thickness and condition at the time of construction. A macadam or gravel road is maintained from time to time by recharging the surface with new material to replace that which has worn away. A brick pavement, on the other hand, cannot be so maintained, but when the surface is worn out, the old brick must be removed and the entire surface relaid. Similarly a sheet asphalt surface is, from period to period, wholly removed from the concrete foundation and a new covering of the original thickness is laid.

"Maintenance," therefore, includes not only "repair" but also an annual charge equivalent to the depreciation of the pavement, such annual charge for depreciation being dependent upon the life of the pavement; or, in the case of a macadam or gravel road, it is the periodic cost of recharging the surface so as to restore it to its original condition.

It is, therefore, to be considered that when comparing the cost of macadam or gravel roads with the cost of a pavement for a period of years, the expenditure for maintaining the macadam or gravel must be offset not only by a charge for annual patching and repairing the pavement but also a charge for depreciation of the pavement.

ROAD CULVERTS IN QUEBEC PROVINCE.*

By Alexander Fraser,
Department of Highways, Province of Quebec.

THE limit of application of the word "culvert" has never been exactly established. In the following I will apply the word somewhat arbitrarily to all work, from the circular culvert of 12 inches diameter to the bridge or culvert of 8 feet span. In the province of Quebec these culverts are considered as an integral part of our roads, and their permanent improvement is made in accordance with the plans and specifications furnished or approved by the Department of Roads. The construction of a bridge of greater dimensions is generally carried out under the control of the Department of Public Works. But when work of a permanent character is projected on the probable line of a provincial road, there is an understanding between the engineers of the two departments as to the location of the bridge in order to secure the best possible alignment.

As the culverts constitute a permanent part of the improvement of our roads, and their cost forms an im-

*Abstract of paper delivered at Third Canadian and International Road Congress, Montreal.

portant item in the total cost of those improvements, special attention to them is necessary, both for good work and for economy. On our provincial roads the average cost of the permanent culverts from 12 inches diameter to 8 feet span has varied from $800 to $1,500 per mile.

In the province of Quebec we build circular culverts from 12 to 36 inches diameter. On our provincial roads all the circular culverts are of concrete. Concrete has passed the experimental stages. But our manufacturers of concrete pipe, at least as far as the province of Quebec is concerned, do not all use the best methods of manufacture. Fortunately, a movement is now under way with a view to the formation of an association of all the concrete pipes manufacturers, like that existing in the United States, whose main purpose will unquestionably be to put on the market a more uniform product.

The quality of the pipes is not, however, the only consideration that can assure to the culvert its permanency and its efficiency. It is also absolutely necessary that they are put into place with care if we want them to give good results. Many foremen or inspectors, not always understanding the importance of every detail, are frequently inclined to overlook some of them in order to save time. Consequently, the need of intelligent and experienced foremen is greater than one is commonly led to believe, because it is often very expensive to repair a culvert when breaks or dislocations are noticed after the pavement is nearly finished.

A culvert has two main purposes: To provide a safe passage to the traffic; and to secure a perfect drainage, while protecting the road.

To provide a safe passage to the traffic, the culvert must have a length equal to the width of the travelled way. This is especially important at the intersections of roads. A reduction in the width of the travelled way at each culvert would be a serious danger, especially where the culverts are numerous, as they generally are along a river or lake. Moreover, the addition of one or two pipes to a culvert in order to provide an adequate length can be done in most cases without increasing the cost of the culvert. The addition of one or two pipes will often permit a smaller headwall to be built, and so effect an economy which will compensate for the additional pipe.

The alignment of the culvert must be such as to permit a rapid flow of water. The introduction of two or four right angles in the line of a ditch, for the laying out of a culvert, as frequently happened in the old structures, must be avoided. If the line ditches at the upstream and downstream side of the culvert happen to be on two different lines of not more than 25 feet apart, we generally prefer to place the culvert at an angle with the centre line of the road, so that its ends will meet the ditches at each side of the road at the best possible angle.

To determine the opening of any culvert, we can take the empirical formulæ of Talbot or Kutter, which are most commonly used, but we must also consider the present dimensions of the old culvert, and the informations (often very important) that can be procured from those living in the locality, who know perfectly well all the local conditions.

The trench excavated for the culvert ought to be at least two feet wider than the external diameter of the pipe to be laid. I have been frequently impressed with the importance of this detail. If the trench has a width hardly more than equal to the external diameter of the culvert, it will be difficult to ram the earth in the lower part, so that it will often not be rammed at all. Consequently, the culvert will not be held firmly in place, and when the rolling starts it will tend to move, the joints will be dislocated and the pipe will frequently break.

We must be careful to give to the bottom of the trench a concave form suitable to the pipe to be placed, so as to ensure to the latter a greater and more uniform bearing surface. The minimum grade of the bottom of the trench will have to be 5 inches per 100 feet, but be at such grade that when the culvert is in place, the water will flow freely at the same grade inside the culvert as it does at the upstream and downstream ends of the culvert. It is very important that all the joints be cemented on both sides, so as to avoid all washouts or caving in of the soil around the culvert.

A very important detail, which is too frequently put aside in practice, is to backfill in parallel and successive layers not more than 6 inches thick, and to ram each layer solidly. This is vital if the culvert is to be prevented from moving and breaking under the roller. The backfilling materials must be carefully selected. The materials taken out of the trench are not always satisfactory. They will frequently have to be replaced by more stable and more dense material, such as clay or coarse sand. Light soils, fine sand or any material containing vegetable matter should never be used.

It is necessary to pave the bottom of the ditch at the upstream and downstream end of each culvert, especially if, on account of a steep grade or of a break in the profile, there is danger of erosion.

We must be careful to leave at least 12 inches of earth over the culvert. If this is not possible, it would be better to lay a cast-iron pipe culvert.

Most of the remarks made with regard to circular culverts apply to the other types of culverts of plain or reinforced concrete, quadrangular culverts, slab culverts, with or without beams, and arch culverts.

A control which cannot be exercised in the case of circular culverts, including control of the mixture, of the quality of materials, and of all the other details in the making of the concrete, can be exercised freely when building larger culverts. With this in view it is important to keep a competent foreman or inspector always at the work. His duties should not be limited to supervision of the proportioning of the mixture and the time of mixing each batch. A mechanical inspection is not sufficient. The theoretical importance of all the details must be well understood.

After the materials have been accepted by the engineer, the inspector or foreman must see that the stone and the sand are always kept clean, that the mixture is methodical, that it is not too wet, etc. He will frequently inspect the forms, to see that they are always kept in line and that they are of correct dimensions. He must see to it that the concrete is steadily rammed to ensure proper density, and that the inner surfaces are smooth.

The alignment of the road must be made judiciously with a view toward the location of culverts. Except where unavoidable, culverts should not be located on curves, specially on curves of short radius. Too frequently culverts have been located to suit the creek, and not enough consideration has been given to providing an alignment satisfactory to traffic.

ENGINEERING AND GOOD GOVERNMENT.

By T. L. Hinckley,
Engineer, Bureau of Municipal Research, Toronto.

VERY few persons, even the most thoughtful, realize how largely the successful administration of a modern city depends upon the correct solution of engineering problems.* While this has always been true in regard to such obvious matters as streets, sewers, bridges, public buildings and the like, it is now true in the case of many municipal activities which have only recently been associated with engineering research. Street cleaning, the heating and ventilation of public schools, the operation of water and sewage purification works, the motorization of fire department equipment, the installation of central testing laboratories, the establishment of municipal refuse destructors, abattoirs, refrigerating plants, the municipal ownership of street railways, power plants, docks, etc., have combined to open up a field of opportunity to the technically trained man of to-day which is as broad as society itself.

Those at the head of our more progressive city governments have had the sagacity to see that in employing the best available engineering talent to supervise and carry out public engineering schemes, a political as well as a practical purpose is served. The economical and efficient performance of public engineering work of any sort reflects credit upon the party, or the administration, which has had the good sense to secure the services of competent, technically trained men rather than to depend upon men whose chief recommendation is a partisan affiliation.

In view of the direct employment by municipalities of engineering talent, engineers who do not happen to be attached to the public service have frequently questioned the propriety of taking more than a passive interest in the technical affairs of their community. Indeed, it is the general rule for engineers in private practice to refrain from offering opinions or advice to local authorities concerning the conduct of local engineering works—except in cases of gross mismanagement—although informal discussions of local engineering matters are, of course, very common. In the writer's opinion, the adoption of such a thoroughly passive attitude in public matters constitutes serious neglect of a function which should be liberally developed, in the interests not only of technical efficiency but of good government.

The man who will not take well-meant advice, be he soldier, financial wizard, engineer or layman, is either a genius or a fool; and it is safe to say that among the technical men employed by our municipalities there are few of either persuasion. There can be no valid reason for municipal engineers or technical experts refusing to accept the advice or suggestions of a body of men of their own stamp upon matters which concern the public welfare—as engineering matters certainly do. The common financial burden which all citizens share in the prosecution of public work of any sort adds strength to the argument that, if properly qualified by education and experience, engineers owe it to their fellow citizens to take a more active interest in the technical affairs of their city, keep themselves informed of the progress of local public work, discuss public work at all professional meetings, appoint committees to study public works in detail, etc.

*Of $1,869,815,000 spent for governmental purposes by 199 United States cities in 1913, fully $1,027,402,000, or 54 per cent., was spent for activities involving engineering work of some sort.

It would perhaps be unwise to suggest that members of engineering professions, in their private capacity only, interest themselves actively in local engineering matters. This should be done officially—as a matter of fact, is now done, on a limited scale, in many cities—by the various professional organizations, as a regular part of their routine. If possible, it should have the approval and co-operation of the regular engineering staffs of the city government. Standing committees should be required to report at each meeting upon the progress of all public engineering or other technical work in the community, and resolutions expressing approval or criticism, as the case may be, should be regularly forwarded to the local authorities.

The chief point of difference between the foregoing suggestion and the present practice of engineering societies lies in the proposal to make the work which such societies do upon public problems *active and continuous* rather than passive or spasmodic—in a word, to put such action upon the basis of citizenship rather than that of professional interest. In this way engineers will not only get the information which they need, as to local public engineering activities, but they will at the same time be rounding themselves out as better and more useful citizens.

QUARTERLY REPORT OF ONTARIO BUREAU OF MINES.

RETURNS made to the Bureau of Mines, Parliament Buildings, by the metalliferous mines and works of the Province of Ontario for the first three months of 1916, show increases in all products except iron ore. Following are the figures, those for the corresponding period of 1915 being added for comparison:—

	January-March, 1915.	January-March, 1916.	Increase.
Gold, ounces	76,307	107,818	31,511
Silver, ounces	5,230,167	5,297,831	67,664
Copper, tons	3,644	5,491	1,847
Nickel, tons	6,680	10,032	3,352
Iron ore, tons	28,332	6,573	*21,759
Pig iron, tons	94,678	160,749	66,071
Cobalt, metallic, lbs. ..	450	36,460	36,010
Nickel, metallic, lbs. ..	.....	11,976	11,976
Cobalt and nickel oxides, lbs.	10,324	143,212	120,888

*Decrease.

The value of the production for the first three months of 1916 was $14,276,382 as compared with $9,358,210 for the corresponding period of last year. This large increase was due not only to the greater output but to the higher prices now prevailing for most of the metals.

Gold.—The increase in the yield of gold was 31,511 ounces, worth $656,872. Compared with the rate of production for the whole of last year the advance was less marked, but developments now under way are likely to lead to a substantial increase. Porcupine provided the bulk of production, namely, 99,282 ounces. Hollinger led in output, followed by Dome, Acme, McIntyre-Porcupine, Porcupine Crown, Vipond, Schumacher and Dome Lake in descending order. The mines situate elsewhere making up the remainder of the yield are Tough-Oakes and Croesus. Consolidation of the Hollinger, Acme and Millerton interests will no doubt lead to a more extensive development and a greater output from these properties.

Silver.—A feature of the quarter was an actual increase in the yield of silver as compared with the first three months of 1915, amounting to 67,664 ounces. In value the increase was proportionately greater, namely, $462,673. This was due to the remarkable rise in the price of silver, amounting to about 50 per cent. over the average figure for 1915. A large part of this increase took place in the latter part of the quarter and afterwards, consequently the benefit of the higher prices was only partially realized during the three months. The natural effect of the advance has been to stimulate both mining and prospecting in Cobalt and to enable low-grade ores in the mines or on the dumps to be worked, which at the former low prices of silver were without value. Nipissing continues to lead in quantity of output; Townsite-City, Seneca Superior, Kerr Lake, LaRose, Coniagas, Cobalt Lake, McKinley-Darragh-Savage, Beaver, etc., follow in the order named.

Nickel and Copper.—The demand for nickel and copper, due to the war, has been insatiable, and the Sudbury mines have shown a capacity for meeting the requirements which could scarcely have been anticipated. The output of nickel and copper in the matte was each 50 per cent. greater than in the first three months of 1915. If the present rate of production is maintained throughout the year, 1916 will see about 40,000 tons of nickel and 22,000 tons of copper turned out by the smelters in the Sudbury district, as against 34,000 tons of nickel and 19,600 tons of copper in 1915. The Canadian Copper Company and the Mond Nickel Company are the producers; the Alexo mine turning out a small quantity of ore which is sold to the Mond Company.

Iron.—The blast furnaces of the province produced about 70 per cent. more pig iron than they did in the first quarter of 1915, and the product was worth almost 100 per cent. more. About 15 per cent. of the iron ore charged into the furnaces was taken from deposits in Ontario, the remainder coming from the United States.

By-products of Silver.—Cobalt oxide and nickel oxide met with a rather better demand, though the quantities exported are still below those of normal times. Metallic cobalt is coming into use, principally in steel alloys, and there is now a small quantity of nickel refined in Ontario from the silver-cobalt ores of the Cobalt camp.

PRESERVATION OF WOODEN POLES.

At a recent meeting of the American Institute of Electrical Engineers, a paper was presented by E. L. Rhodes and R. F. Hosford, on recent results obtained from the preservative treatment of telephone poles. The paper covered the experience with treated poles over a period of eighteen years in the plant of the American Telephone and Telegraph Company and their associated companies, in the use of distillates of coal tar or wood tar for preservative treatment. The authors sum up the results of their experience in the following conclusion: "Because of the present incomplete stage of our experience with the different types of treatment described, conclusions can be reached for only a part of the problems whose solution was sought. The seasoning of poles offers at best only moderate advantages in the way of increased life. Its greatest value is as a preparation for the successful application of preservatives. The practice of applying to poles preservatives high in antiseptic power and insoluble in water has been shown to yield increased life. The amount of preservative applied and the depth to which it is made to penetrate appear to exercise controlling influences upon the results obtained. Mechanical failure of the treated layer is indicated as the principal limit to the effectiveness of light applications of preservatives."

SPHERICAL BEARINGS *versus* FLAT PLATES IN CRUSHING TESTS ON BRICKS.*

By E. L. Baker and Alex. F. Suss.

It is the opinion of the investigators that there is an error introduced in the omission of a spherical bearing in compression tests of bricks. Although the error introduced by the omission of a spherical bearing may not be great enough to be of any practical significance, it is true that the theoretical crushing strength can only be obtained by the use of some device which will take care of non-parallelism of the compressive surfaces, thereby preventing the development of internal stresses in the specimen and the spalling-off of the specimen on one side.

It is the aim of the investigators to prove by these tests that the crushing strength of bricks is greater as obtained by the use of some type of spherical bearing than by the use of flat plates. In the first one hundred and seventy-three tests we have determined this difference by using flat plates and the one-piece spherical bearing. In order to have relative values we first made the ordinary cross-breaking tests, thus obtaining two halves of the same brick to be used in crushing.

One-half of the brick was crushed with the one-piece spherical bearing and the other half with the plate bearing. It is obvious from an inspection of paving bricks that no two bricks are alike. They are not homogeneous, they are not burned to the same degree of hardness, and their surfaces have different degrees of non-parallelism. Therefore, by using the two halves of the same specimen as described, we have obtained comparative values showing the difference between results as obtained by the use of the one-piece spherical bearing and flat plates.

The reader may be impressed by the wide variation in the result of these tests. The only explanation we can give for such variations is that already given, differences of homogeneity and burning. Arch bricks will necessarily be overburned, while those of the interior of the kiln may be underburned. In ordering the bricks for these tests we called for 2¼-in. by 4-in. by 8-in. vitrified paving bricks to be taken at random from any part of the kiln, thereby obtaining a sample of brick which would ordinarily be sent out on a job.

The machine used was a Riehlé Brothers, 200,000-pound, two-screw machine. The poise was run by hand. The cross-breaking test was made according to the method given in Johnson's "Materials of Construction." The brick was set edgewise on two rounded, knife-edge bearings placed six inches centre to centre and loaded in the middle. The modulus of rupture was found by applying the formula

$$f = \frac{3}{a}\frac{W l}{b h^2}$$

where

f = modulus of rupture in pounds per square inch.
W = ultimate load in pounds.
l = distance between knife edges in inches.
b = width of brick in inches.
h = height of brick in inches.

In order to have an approximately uniform cross-section for the crushing tests, it was necessary to surface the bricks after cross-breaking them. This was accom-

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plished by chipping the surfaces with a cold-chisel and hammer. During the surfacing the specimen was kept on a wooden block and the hammer-blows were made as light as possible to be effective in order that the brick would suffer no injury.

The bricks were then calibrated. Six measurements were made on each dimension of the bricks in order to obtain a true average dimension. The halves were then tested with the one-piece spherical bearing and flat plates. Two smoothly surfaced plates, 10 ins. by 10 ins. by ½ in., were used, one placed on the base of the machine, upon which the specimen was centered, the other resting upon

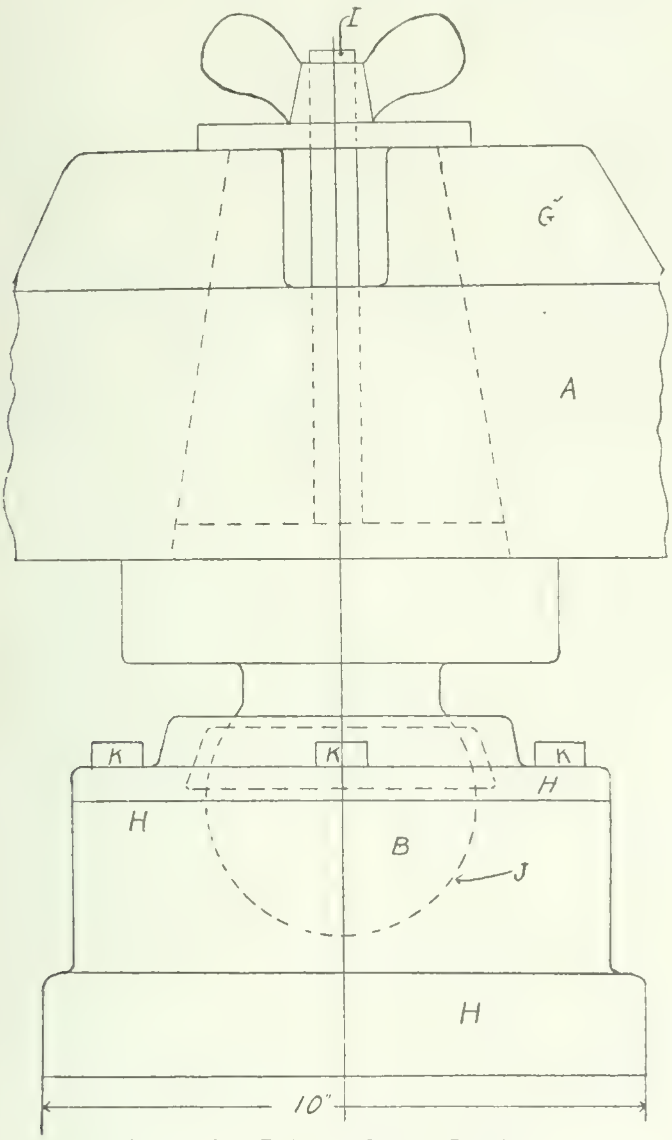


Fig. 1-A.—Ball-and-Socket Bearing.

the specimen. The one-piece spherical bearing is of cast steel, one surface of which is flat and the other spherical, having a radius of approximately 10 inches. The spherical surface rested on a flat plate on the base of the machine, the brick was centered on the flat surface of the bearing, and another flat plate was placed between the specimen and the head of the machine. The machine was run at low speed during the tests in order to secure a slow and uniform increase in load. The majority of the specimens failed all at once with a loud report, only a few spalling off and crushing without an increase in load. The crushing strength per square inch was computed by dividing the total load by the cross-sectional area of the brick.

A table has been prepared showing the results of these tests which will be furnished by the authors to any investigators who wish to use them in any further studies along these lines. In these tables are shown the modulus of rupture, crushing strength between plates, crushing strength with one-piece spherical, and the ratio of the crushing strength as obtained with the spherical bearing to that obtained with the flat plates.

One hundred and forty-seven tests were made with the one-piece spherical bearing and a ball-and-socket bearing made by Riehlé Brothers, of Philadelphia, and shown in Figs. 1-A and 1-B. F is a cast-iron cup which rests upon the base of the machine; D is a flat steel plate 10 inches in diameter, the underside of which, E, is semi-spherical and rests in the cup F. Before placing this bearing in the machine, the surfaces of E and F, which are in contact, were thoroughly lubricated with hard-oil in order that they would slide upon each other as freely as possible, thereby eliminating the friction between these surfaces. Parts A, B, G and H form the unit which is held in the head of the machine by the bolt, I, and thumbscrew. B and A are one solid casting, B being milled perfectly spherical to fit into a semi-spherical socket, J. The casting, H, is in two parts, as shown, and is held in position by four screws, K. The ball, B, and socket, J, were kept well lubricated with hard-oil. The advantage of this bearing is that there can be no flexure in the specimen regardless of how non-parallel the compressive surfaces may be.

The specimens used in these tests were cross-broken and calibrated in the same way as the specimens in the previous tests.

In order to make an intelligent study of the advantages of the spherical bearing, it is necessary to compare the values obtained by testing the two halves of each individual brick. In each case in the first one hundred and seventy-three tests we divided the spherical test value by the plate test value and set up a ratio for each brick. The average of these ratios should substantiate the theoretical advantages of the spherical bearing if enough tests are made to eliminate differences in material and accidental errors in testing. In the remaining tests the ratio was obtained by dividing the crushing value obtained from the test with the ball-and-socket bearing by that obtained from the test with the one-piece spherical bearing.

In obtaining points for a curve showing the relation between the unit crushing strength and the ratio of height to least dimension we found the average crushing strength of all the specimens having the same ratio.

Results of Tests.

1. The average ratio for the tests made with the one-piece spherical bearing and flat plates is 1.03.

35% of tests were within 10% of the average ratio.
22% " " " between 10% and 20% of average ratio.
16% " " " " 20% and 30% " " "
8% " " " " 30% and 40% " " "
8% " " " " 40% and 50% " " "
11% " " " not within 50% " " "

2. The average ratio for the tests made with the ball-and-socket bearing and the one-piece spherical bearing is 1.12.

12% of tests were within 10% of the average ratio.
30% " " " between 10% and 20% of average ratio.
17% " " " " 20% and 30% " " "
18% " " " " 30% and 40% " " "
9% " " " " 40% and 50% " " "
14% " " " not within 50% " " "

3. Average unit crushing strength obtained from the flat plate tests is 8,[illegible] pounds per square inch. The average unit crushing strength obtained from the one-piece spherical bearing tests on the remaining halves of the same bricks used in the flat plate tests is 8,380 pounds per square inch.

A. Flat plate tests—

35% within 10% of average crushing strength.
20% between 10% and 20% of average crushing strength.
18% " 20% and 30% " " " "
18% " 30% and 40% " " " "
5% " 40% and 50% " " " "
4% not within 50% " " " "

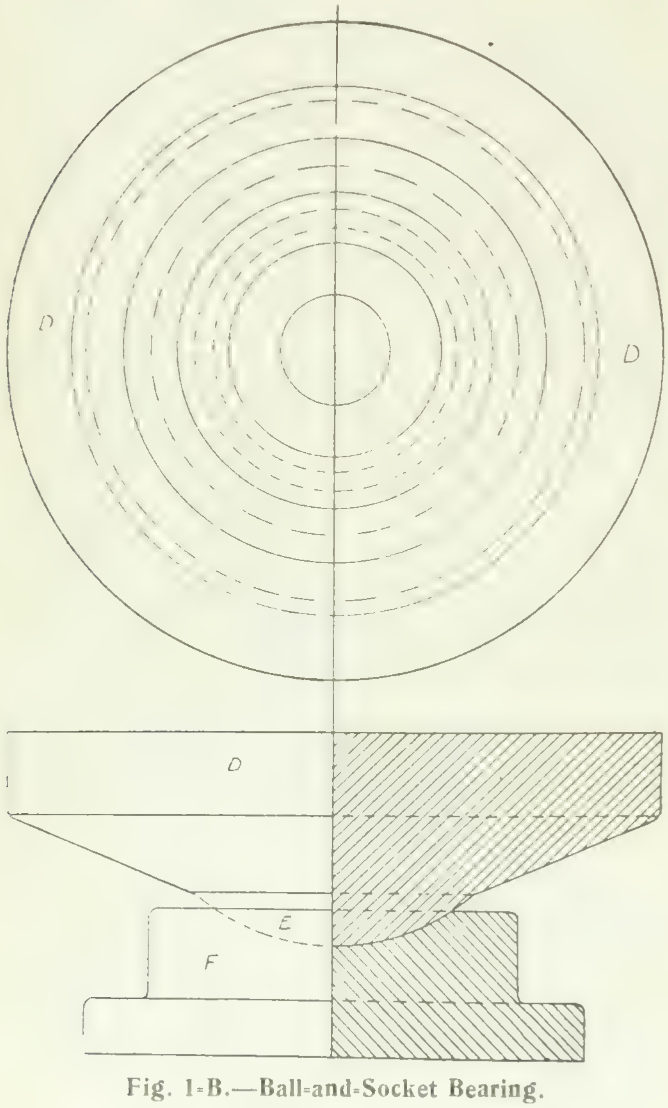


Fig. 1-B.—Ball-and-Socket Bearing.

B. One-piece spherical bearing tests—

9% within 10% of average crushing strength.
25% between 10% and 20% of average crushing strength.
21% " 20% and 30% " " " "
21% " 30% and 40% " " " "
1[illegible]% " 40% and 50% " " " "
8% not within 50% " " " "

4. The average unit crushing strength obtained from the ball-and-socket tests is 9,340 pounds per square inch. The average unit crushing strength obtained from the one-piece spherical bearing tests on the remaining halves of the bricks used in the ball-and-socket tests is 8,[illegible] pounds per square inch.

A. Ball-and-socket tests—

26% within 10% of average crushing strength.
19% between 10% and 20% of average crushing strength.
20% " 20% and 30% " " " "
14% " 30% and 40% " " " "
10% " 40% and 50% " " " "
11% not within 50% " " " "

B. One-piece spherical tests—

31% within 10% of average crushing strength.
31% between 10% and 20% of average crushing strength.
15% " 20% and 30% " " " "
13% " 30% and 40% " " " "
5% " 40% and 50% " " " "
5% not within 50% " " " "

Conclusions.

1. The fact that the ratio, 1.03, was obtained from the comparative tests with the one-piece spherical bearing and flat plates, shows that the one-piece bearing has an advantage over the flat plates.

2. The ratio, 1.12, obtained from the tests with the ball-and-socket and one-piece spherical bearing shows that the ball-and-socket bearing has an advantage over the one-piece bearing.

3. We recommend for an average crushing value for vitrified paving bricks that value obtained from the tests with the ball-and-socket bearing, which is 9,340 pounds per square inch.

4. The average modulus of rupture is 2,600 pounds per square inch.

SPECIFICATIONS FOR PILES AND POLES.

Of interest to engineers and engineering contractors are the following proposed tentative specifications of the American Society for Testing Materials, reported for discussion at the last meeting in Atlantic City.

No pile with butt diameter over 18 ins., nor top diameter over 13½ ins. will be accepted. The length of each pile is to be legibly marked on the butt with white or black paint.

1. The specifications as to strength shall agree with the requirements that will be finally adopted by the Society under the Standard Classification of Structural Timber; that is, number of rings per inch or some substitute therefor. (Included in this section will also be a list of the allowable defects, etc.)

2. All piles or telegraph poles shall show 40% sapwood in cross-section, or there shall be a ring of sapwood not less than 1 inch in thickness all around the heartwood.

3. (*a*) Piles and poles shall be cut from sound, live trees, of straight grain and regular taper; without crooks exceeding one-fourth the diameter of the stick at middle of crook when peeled. They shall be free from rot, red heart, holes or rotten knots, shakes and felling checks. (*b*) All piles and poles shall have the bark and inner skin carefully removed when the tree is felled; all limbs and knots trimmed flush and butts cut square.

4. The minimum diameter of piles after peeling shall be as follows:—

Length.	Butts.	Tops.
36 ft. and under	14 inches	10 inches
38 ft. and under 50 ft.	14 "	9
50 ft. and over	15 "	9

IRRIGATION SURVEYS AND INSPECTIONS.

THE following article is extracted from the report recently sent out by the Irrigation Branch of the Department of the Interior, (E. F. Drake, superintendent). In view of the economic importance to a country like Canada of this branch of engineering work, the observations made by Mr. Drake and also by F. H. Peters, Mem.Can.Soc.C.E., commissioner of irrigation and chief engineer, in the report referred to will be of interest.

Inspections.—The usual inspection work was continued throughout the year, and careful inspections were made of all irrigation and water supply works either licensed or under construction. Inspections were also made to determine the feasibility of projects for which applications had been received. The increasing demand for water for domestic, municipal, and industrial purposes has necessitated a good many careful inspections to determine the existing rights, or claims to water from the streams or springs affected; and in many cases it has been found necessary to either refuse applications or to suggest other sources of supply. In the southern portions of the provinces of Alberta and Saskatchewan the smaller streams are now in many cases fully appropriated and as the demand for water increases, as it must with continued development, the question of supply will become serious. Water must then be brought from greater distances, at increased cost, or resort must be had to deep boring and expensive pumping plants.

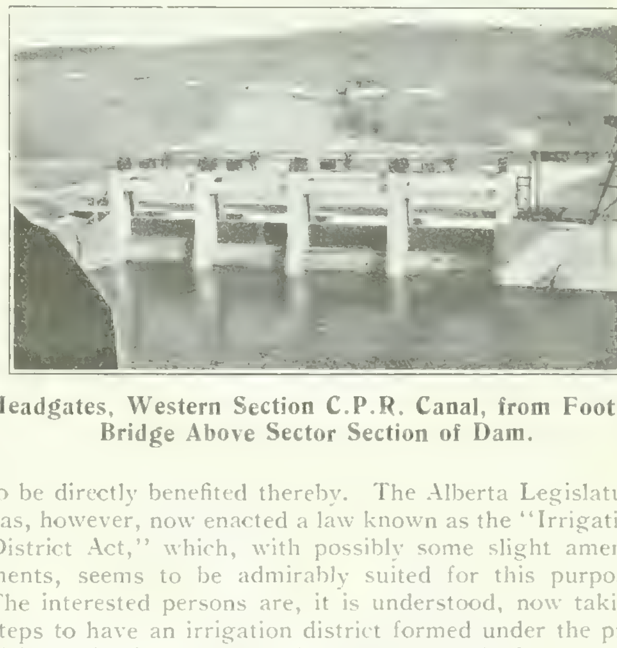
Surveys.—Four large parties were employed throughout the entire field season of 1914 in further developing surveys initiated during the previous year. Three of the parties were engaged in canal location and level work in the development of the feasibility of irrigating land in southern Alberta, south and east of the city of Lethbridge, while the fourth party was engaged in completing the preliminary development of an irrigation project north of Lethbridge.

The Alberta Railway and Irrigation Company, now controlled by the Canadian Pacific Railway Company, operates an irrigation system taking water from St. Mary River in township 1, range 25, west of the 4th meridian. The land irrigable from this system is in the vicinity of Magrath, Stirling and Lethbridge, and comprises some 170,000 acres, not all of which, however, has yet been actually irrigated. The entire district south of Lethbridge and extending eastward to the eastern boundary of the province is in the so-called dry belt and is, generally speaking, well adapted to irrigated farming. The purpose of these surveys is to fully develop the available sources of water supply, to locate possible canal routes, and to determine, in a general way, the areas commanded by such canals. The work is regarded as of great importance to the development and settlement of a very large district. It contemplates the fullest possible utilization of the available water supply from St. Mary, Milk, Belly and Waterton Rivers, including reservoirs for the conservation of flood waters, and the carriage of the water to and through the districts that can be served therefrom.

During the season of 1913 a preliminary survey was made to demonstrate the feasibility of diverting water from Belly River to St. Mary River at some point above the intake of the Alberta Railway and Irrigation Company canal. During the season of 1914 these surveys were extended with a view to developing canal routes and irrigable areas east of St. Mary River. These parties were employed, and during the season they ran 1,259 miles of level lines, 512 miles of complete traverse and level lines, 300 miles of contour surveys, developed three reservoir sites and one dam site, and set ninety-two permanent iron bench-marks. Complete reports, with plotted plans, have been submitted, but these are as yet merely preliminary studies. It is anticipated that by the end of the season of 1915 the work will be sufficiently advanced, if not completed, to warrant a full report.

Work was continued throughout the year on the project contemplating the diversion of water from Oldman River for the irrigation of several detached tracts north of Lethbridge, comprising a total area of about 100,000 acres. The preliminary work of canal and reservoir location, and the determination of the commanded areas, was completed during the season of 1914. Over 1,200 miles of level lines and some 200 miles of complete traverse and level lines were run.

Portions of the district comprised in this project suffered severely from drought in 1914, and the settlers have urged upon the department the completion of the surveys and the actual construction of irrigation works. Unless, however, the government is prepared to adopt a policy of construction and operation of irrigation works—and for many reasons this seems undesirable—there was until very recently no legislation under which such a project could be initiated, financed and constructed by the persons to be directly benefited thereby. The Alberta Legislature has, however, now enacted a law known as the "Irrigation District Act," which, with possibly some slight amendments, seems to be admirably suited for this purpose. The interested persons are, it is understood, now taking steps to have an irrigation district formed under the provisions of this law, and will probably apply for a water right in the near future.



Headgates, Western Section C.P.R. Canal, from Foot of Bridge Above Sector Section of Dam.

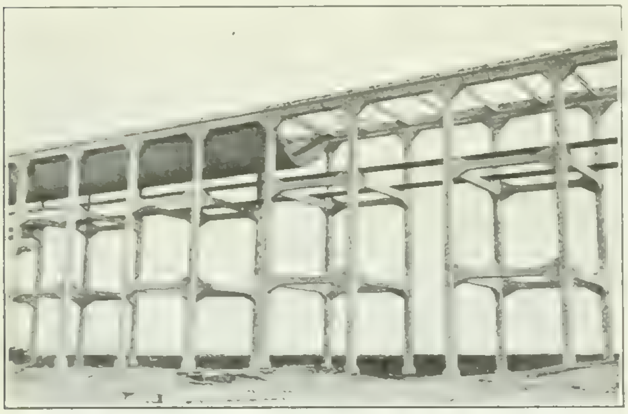
In the meantime further surveys are being made to more accurately define the irrigable lands with a view to apportioning the cost of the necessary works on the lands to be benefited. Some opposition to the scheme has developed, particularly in the western part of the district nearer the mountains, where the soil is somewhat heavier and the rainfall possibly greater. The extent of the opposition has not yet been fully developed, and it is too early to express any opinion as to whether or not it will be serious enough to jeopardize the entire project.

In the early autumn of 1914 the attention of the department was drawn to the scarcity of water for domestic use in the district lying east of Little Bow River in townships 12 and 13, ranges 18 and 19, west of the 4th meridian. It was suggested that it might be found possible to utilize the uncompleted works of the Southern Alberta Land Company for the carriage of water from Bow River, and that

canals might be run from the company's main canal through the district referred to, thus supplying water for domestic and stock-watering purposes and for irrigation as well.

Surveys made during October and November, 1914, demonstrated the feasibility of diverting water from the Southern Alberta Land Company's canal so as to serve approximately 93,000 acres in townships 14 to 17, ranges 18 and 19 (70,000 acres), townships 12 and 13, ranges 18 and 19 (13,000 acres), and township 11, range 17, west of the 4th meridian (10,000 acres), and to supply water for domestic purposes during the summer season throughout the district. Unfortunately, however, the works of the Southern Alberta Land Company are not at present sufficiently advanced to permit of the carriage of water to the points at which the diversion canals must head, and the financial difficulties which have hampered the company's operations for some time past preclude the expenditure at present of the sum necessary to place the works in serviceable condition.

The surveys have, however, served a useful purpose, and when the Southern Alberta Land Company is able to complete its works so as to serve the most westerly unit



Brooks Aqueduct, Bantry Canal, Eastern Section C.P.R.

of its irrigation tract, there is reasonable probability of an arrangement being made for the use of these works in the carriage of water to the district referred to. There is no question but that the district requires irrigation for its fullest development, and that the domestic water supply can be greatly improved by the construction and operation of irrigation canals.

It is understood that officers of the Geological Survey are making an examination of this and other districts in southern Alberta with a view to determining the depth at which water for domestic and other purposes can be obtained.

Reservoirs.—One of the most important questions that has recently engaged the attention of the engineers of this branch is the location and survey of reservoir sites for the conservation of flood water. Several large reservoir sites were located some thirteen years ago by engineers in the employ of the Alberta Railway and Irrigation Company, and it was apparently intended that some of these sites should be used in the development of the company's irrigation system in the Lethbridge district. Only one of these, the Chin Coulee reservoir, has been constructed. Our engineers have examined several of these sites with a view to their utilization for the storage of flood water from St. Mary and Milk Rivers in the development of irrigation in southern Alberta, and with special reference to the division of the waters of these streams between Canada and the United States in accordance with the provisions of the "Waterways Treaty."

Other possible reservoir sites on the headwaters of Belly and Waterton Rivers have been examined in a preliminary way, and detailed surveys will be made as soon as opportunity offers.

In the Cypress Hills district—that is, the district in southwestern Saskatchewan and southeastern Alberta, between the international boundary and the main line of the Canadian Pacific Railway—there are many irrigation projects which are dependent for water supply upon streams which usually are dry, or nearly so, just when water is most needed, but which have a very considerable flow in early spring or after heavy rains. Under existing conditions, irrigated farming cannot be satisfactorily carried on. Frequently only one irrigation can be given, and that earlier than is desirable, while if the flood waters which are now wasted could be stored, a greatly increased acreage could be brought under cultivation and satisfactorily irrigated.

Our surveys have developed three large reservoir sites, *viz.*, Cypress Lake in township 6, ranges 26 and 27, west of the 3rd meridian, where it will be possible to store the flood waters of Battle Creek and Frenchman River, including their upper tributaries; Middle Creek reservoir, on a tributary of Lodge Creek, and a large reservoir on the lower course of Frenchman River in township 5, range 16, west of the 3rd meridian.

The Cypress Lake and Middle Creek reservoirs were fully reported upon last year. The Frenchman reservoir was surveyed during 1914. It covers 3,500 acres and can be developed to hold 50,000 acre-feet of water. These three reservoirs, supplemented by smaller ones on some of the tributary streams, will give fairly good control of the flood discharge of the streams flowing south from the Cypress Hills, and provide for the irrigation of large areas of land. Their early construction is urgently required, and it is the desire of the settlers that it shall be undertaken quickly.

There are no large streams flowing north from the Cypress Hills, but several small reservoir sites have been located and a few of them have been carefully examined. Possibly some additional sites may yet be discovered. A good many small irrigation projects draw their water supply from these streams, but no general policy of water conservation seems possible. Probably the problem can best be handled by the construction of small reservoirs whenever possible, and the sharing of the cost among the few whose water rights will be improved thereby. The Dominion Government may be able to assist by reserving the vacant Dominion land required for any such reservoir—and some such reservations have already been made—but as almost all the land affected is now in private ownership it will be necessary for the interested parties to deal directly with the owners and to arrange among themselves for sharing the cost of the work. This branch will be prepared to assist by placing at the disposal of the interested parties all data already collected, including plans of such surveys as have been made.

Domestic Water Supply.—In some districts in the provinces of Saskatchewan where the domestic water supply problem has become acute, the Provincial Government has constructed a number of small reservoirs, or dugouts, which while not ideal sources of water supply, serve a useful purpose in providing water for stock and for the operation of farm machinery. In cases where such reservoirs are built on well-defined streams, and where the storage of water would have an appreciable effect on the volume of water on the lower course of the stream, the

government should—and usually has—acquired a water right under the provisions of the Irrigation Act. In many cases, however, such reservoirs are merely natural depressions which have been deepened to hold surface water, and there seems to be no necessity for the acquisition of water rights. The purpose of the Irrigation Act is to vest in the Dominion Government the ownership of all sources of surface water supply, with a view to the administration of the law so as to best serve the general public interest, and it is not the policy of this department to impose any unnecessary restrictions upon the conservation and use of water.

Duty of Water and Demonstration Work.—A very important feature of irrigation administration is the determination of the quantity of water required to produce the most beneficial results when applied for irrigation. The existing regulations define the "duty of water," or the ratio between a given quantity of water and the area of land it will irrigate, as 150 acres for each cubic foot of water per second flowing constantly throughout the irrigation season of 153 days. This quantity is equivalent to about two acre-feet of water for each acre of land irrigated, or enough to cover each acre to a depth of two feet. The best modern practice inclines towards expressing the duty of water in depth over the irrigated tract, rather than by the rate of flow, and in the revised regulations now in course of preparation the duty is defined as two acre-feet per acre, an acre-foot being equivalent to 43,560 cubic feet.

This depth may be, and probably is, too great. The duty was established some fifteen years ago and was based upon experimental work carried on principally in the Western United States. Experience has shown that there has been a general tendency on the part of irrigators to use too much water, and that the result in many cases has been to sour and waterlog the land, or to cause the rise of alkali to such an extent as to temporarily ruin the soil. Some experimental work was done in Canada several years ago, and in 1913 it was taken up in a systematic manner with a view to determining the quantity of water required to produce the most beneficial results for different crops under the varying conditions of soil and climate in the dry belt of Western Canada.

Absorption Losses in Irrigation Canals.—A question which has received too little attention in the past is that one dealing with the inevitable losses which occur on every canal system in conducting the water from the source of supply to the farmer's headgates, due to seepage and evaporation in the main, secondary, and tertiary canals. During the irrigation season one hydrometric engineer, Mr. R. J. McGuinness, was employed in making measurements with a view to determining these losses in the canals of the C.P.R. western section and the Alberta Railway and Irrigation system at Lethbridge. The work is very complicated owing to many practical difficulties which arise in the field, but during the season data were gained which, while not entirely satisfactory, have made it possible to determine the average "absorption" losses between certain limits.

Hydrometric Surveys.—This work, covering the measurement of the flow in all the important streams in Alberta and Saskatchewan, has a very wide scope and it is only possible in this summary report to indicate the work that has been carried out. The results of the work in detail will be published in a separate report on Stream Measurements.

The work was carried out under the charge of Mr. P. M. Sauder, chief hydrometric engineer, with two principal assistants, Mr. G. H. Whyte and Mr. G. R. Elliott. The office staff consisted of two office computers and recorders, and twelve hydrometric engineers were employed in the field.

The districts covered were the same as described in the previous year's report, with the addition of the Wood Mountain district, which comprises a number of streams which rise in Saskatchewan and flow across the international boundary, and are of considerable importance for this reason. During the season records were gained for 164 permanent gauging stations, 3,550 stream measurements were made by the field engineers, 29 new permanent stations were established, and 24 permanent iron benchmarks were set.

On many of the smaller irrigation streams in Saskatchewan and Western Alberta a very high percentage of the run-off takes place in the early spring due to the melting and rapid run-off of the winter's snow. Previously the hydrometric engineers had not taken the field early enough in the spring to measure this flow, but during the spring of 1915 a special effort was made to obtain these very important measurements. In order to handle this work, eight hydrometric engineers took the field early in March and gained very valuable measurements. Six engineers were placed in the Cypress Hills district, one north and four south of the hills, another operated along the line of the Canadian Pacific Railway between Medicine Hat and Maple Creek. The hydrometric engineer in the Wood Mountain district took the field as early as possible, but owing to the difficulties of getting into this district did not get the peak measurements on all of the streams.

Crawling Valley Dam, Eastern Section C.P.R.

HUDSON BAY RAILWAY.

Estimates of the department of railways, among them appropriations of $3,000,000 to carry on the construction of the Hudson Bay Railway and its terminals at Port Nelson, and $1,500,000 for work on the National Transcontinental Railway, were passed by the commons in committee of supply this week. The discussion centred around the vote for the Hudson Bay Railway, some members still having doubts as to the practicability of the road as a grain route, and the suitability of Port Nelson as its terminus.

Mr. Robb (Huntingdon) feared that the season of navigation on Hudson's Bay and Straits would not be long enough to permit of the railway being of much use in moving the western grain crop.

Hon. J. D. Reid, who estimated that the project would cost in all $26,000,000, and would be completed in the autumn of 1917, declared himself convinced that the railway would prove of value to the country.

Hon. George P. Graham asserted that it would be of value in opening new territory and should be built, even if there were no exports for it to move to the point of embarkation.

THE TYPHOID TOLL.*

By George A. Johnson.

CERTAIN cardinal facts stand forth in opening a discussion of the significance of typhoid fever. First of all, let it be clearly understood that there is no question of its being an entirely preventable disease. Second that all typhoid is caused by taking the typhoid germ into the mouth. And, third, that typhoid fever in America is the chief disease conveyed by impure food and drink.

These premises stated, let us go a little further in the line of elaborating on these basic facts. Since the disease cannot be contracted naturally without taking the specific germ into the mouth, and since the manner in which this act is commonly performed can be said to be associated almost exclusively with the consumption of typhoid infected food and drink, it follows that to eradicate the disease involves only the exercise of really simple measures of precaution, which, in the concrete, are to see to it that the food and drink be pure, or made pure, and kept pure until consumed. Public understanding of this need is, of course, in the ideal sense, imperative, but when once the typhoid scourge has been placed under control, it is possible for public health authorities to prevent the reëstablishment of its sinister influences on the public health, in spite of the ignorance, selfishness, or almost unbelievably complacent tolerance of the public itself.

It is not for a moment denied that to effect this idealistic result is an undertaking beset with tremendous difficulties. The public is not to be blamed unqualifiedly for individual or collective responsibility in the maintenance of this filth disease among human kind. Education must be forced upon the public by those qualified to teach; public health officials must be given wider power through more exact and far-reaching laws aimed at the destruction of the roots of this filth-sustained plant; and ample funds must be appropriated to carry through the work. The vital capital needlessly dissipated by the typhoid scourge in this country amounts each year to not less than $150,000,000, yet the combined annual appropriations for all the health departments of the cities of the United States amount to less than 30 cents per capita, or not more than $15,000,000. This fund is made to cover the expenses of work on infant morbidity, inspection of school children, laboratory and dispensary service, tuberculosis, and for educational and publicity work, and this sum is clearly inadequate for the efficient prosecution of tuberculosis work alone. In New York City a very large share of the expense of such work is borne by the Department of Charities. Probably not 10 per cent. of the health department funds are devoted to holding typhoid fever in check; the prevention fund, if you like. Such an amount would be equal to 1 per cent. of the loss suffered through failure to exercise adequate and efficient measures of prevention.

If the adjuster of a municipal or state budget were knowingly threatened with illness, or one of his immediate family so affected, he would not hesitate to spend any reasonable sum of money to defray the cost of obviously necessary preventive measures. Life insurance certainly is popular, and it is not to be supposed that the officials of city and state finance departments are immune to the persuasive arguments of life insurance agents. This is protection against the effects of disease; nevertheless, such officials wield an energetic blue pencil when they reach the health department item in the annual budget. They cannot see the return of good to the public, even though they realize the protection afforded to themselves and their families from their life insurance, or they would not pay the premiums.

Twenty millions of people in the United States are now being furnished with filtered water at a cost not exceeding $8,000,000, or 40 cents per capita, per year, and in these cities having filtered supplies the water-borne typhoid fever has been practically eliminated, as reliable statistics abundantly prove. Inexpensive as water purification is, these people are spending more money for that alone than they appropriate for the work of prevention and public treatment of all diseases, whether water-borne or not, and it is not to be forgotten that out of the public health fund comes a considerable expenditure for work in the line of the conservation of purity of public water supplies.

The results of water purification always show a big balance on the right side of the ledger. Where one dollar is spent for pure water, many dollars are saved in the form of vital capital through the prevention of sickness and death. If a community of 19,000 people spends each year 40 cents per capita for filtered water, and thus each year prevents a single death and the attendant cases af illness from typhoid fever, it will come out even financially, and increase its self-respect into the bargain. In Pittsburgh, to cite a well-known example, the adoption of water filtration has saved over 600 lives, 9,000 cases of typhoid illness, and $4,500,000 in vital capital annually.

Whose is the responsibility? Who can be blamed for permitting typhoid fever to exist and thrive in this enlightened age? Is it the national government, the state governments, the municipal governments, or the people themselves? There is no law prohibiting the consumption of impure water or food unless the consumer deliberately contemplates suicide.

A community may start out with the best intentions. Legislative enactments are put through to protect the public health. This is simple, for none but the framers of health laws really know what they signify, hence there arises no antagonism to their enactment. Next comes the task of obtaining the necessary funds to enforce these laws. The average appropriation of all the cities where such funds are made available is, in round numbers, 30 cents per capita per annum. This applies only to those cities having populations of 25,000 or more. What of the remainder?

Let any thinking citizen ask himself if he considers a contribution of 30 cents each year on his part sufficient justification for his assurance of protection against preventable disease. Or, as another example, if he thinks, if given in charity, it is his proper share toward the fund for keeping in check and preventing the spread of the great white plague, which kills 130,000 people in America each year. Unquestioningly, he would give far more to street beggars in the course of a year. If every man, woman and child in the United States contributed one dollar each year to public health work, the total sum thus raised would not nearly equal the annual loss in vital capital in this country from typhoid fever alone. Not one city in America does contribute one dollar per capita for all the uses of its health department, but on an average contributes the far-famed thirty cents, which is opprobrium enough.

*Extracts from a paper read before the American Waterworks Association, June, [illegible]

In the states best off with respect to health laws recorded on their statute books, the proper enforcement of these laws is never carried out. Observe the anti-spitting law enacted only a few years ago. No law was more proper, but in the beginning, when an arrest for its violation was made, it was so unusual a proceeding that the ensuing brief court proceedings were likely to find their way to the front page of the newspapers, and for days thereafter the cartoonists were busy with their humorous pencils creating and nursing a spirit of mockery, so often fatal to the public good. The law prevailed, nevertheless, more through the effects of ingenious placarding of the statute than a fear of legal apprehension, or an honest belief that disease was spread in this manner.

Laws looking to the prevention of contamination of food and drink commonly are allowed to lie peacefully within the covers of the books of law, seldom to be disturbed. The screening law, calling for the protection of foods exposed for sale from the explorative activities of the deadly house fly, was observed where there was no apparent way out of it, but the screens, when provided, were often improperly constructed, and since they were more or less of a nuisance to the owner in disbursing his wares, were never more than partly effective.

Campaigns for Pure Water Supplies.—No one can gainsay that in progressive states the majority of the movements looking to the improvement of public water supplies originate in the health department. Especially is this true where the community is small, and where the water department officials do not feel warranted in employing relatively expensive men who are technically trained in water analysis and matters in general relating to water pollution. Then, too, the officials of large cities often are slow to act in such matters, and too prone to fall back upon arguments based on the financial inability of the community to carry through the construction of water purification works. It can be stated unqualifiedly that no community, whatever its size, is too poor to have a pure water supply. It is better to have had streets, grade crossings, and inadequate public buildings than to tolerate a public water supply of questionable purity.

Grade crossings are a menace to life, to be sure, but not nearly as great a menace as a bad water supply; and they are more often abolished for the sake of convenience than as a measure of public safety. Good streets promote business and the public comfort, but such improvements do not measure up on a level of importance with a supply of pure water. Attractive, roomy and light public buildings are a matter of common civic pride, but it is doubtful if they tend materially to increase the efficiency of those who labor therein.

Of all public works, the waterworks is by far the most important, and should always be given preference in the allotment of moneys for the city's maintenance. Ever since it became known that bad water was dangerous to health the public has been entitled by sovereign right to receive pure water. Bad water will put out conflagrations as promptly as pure water, but it also will cause widespread disease, which is more important. In the last thirty odd years the loss in vital capital through typhoid fever alone was over three times the net property loss from fire in the United States.

It is the customary design that the waterworks department of a community shall be self-supporting, but it is rare that large sums of money are kept on hand to defray extraordinary expenses in the department. When questions arise as to the adequateness of the supply as regards volume, or more satisfactory distribution, little difficulty is experienced in obtaining the necessary funds to carry out the work, for the comfort and convenience of the public are affected. With improvements in the supply respecting purification it is different. When a city of a hundred thousand people is confronted with evidence furnished by its own officials and those of the state health department showing that the water supply requires purification, and learns that works to effect this end will cost, say, $300,000, there follows an energetic sharpening of pencils to ascertain how this is going to affect the tax rate. There is strong opposition to the movement from the very beginning.

The state health officials, realizing the necessity better than anyone else, order that purification works be built. The cost thereof being estimated, the matter of a bond issue to carry the expense is put up to the people, and very often is defeated. Then an extension of time is allowed, and the matter drifts along for years without any definite advance.

Many cities have endured an excessively high typhoid fever death rate for years, and withheld the financial support necessary for the furtherance of measures of prevention, even when it was plain that the public health of the community would be immensely benefited thereby. Great cities, such as Baltimore, Cincinnati, Louisville, Minneapolis, Philadelphia, Pittsburgh, St. Louis and Washington, temporized with the matter for years before building purification works, and in the meantime thousands of their citizens were needlessly killed by water-borne diseases. Then they built filter plants, and it is safe to say that if a candidate for public office in any of these cities should advocate the abandonment of filtration, he would stand as much chance of election as the proverbial snowball has of existence in Gehenna. The people in these cities now realize what pure water means to them, and while at first reluctant to believe, actual experience of the benefits has turned their minds just as far, or farther, in the opposite direction.

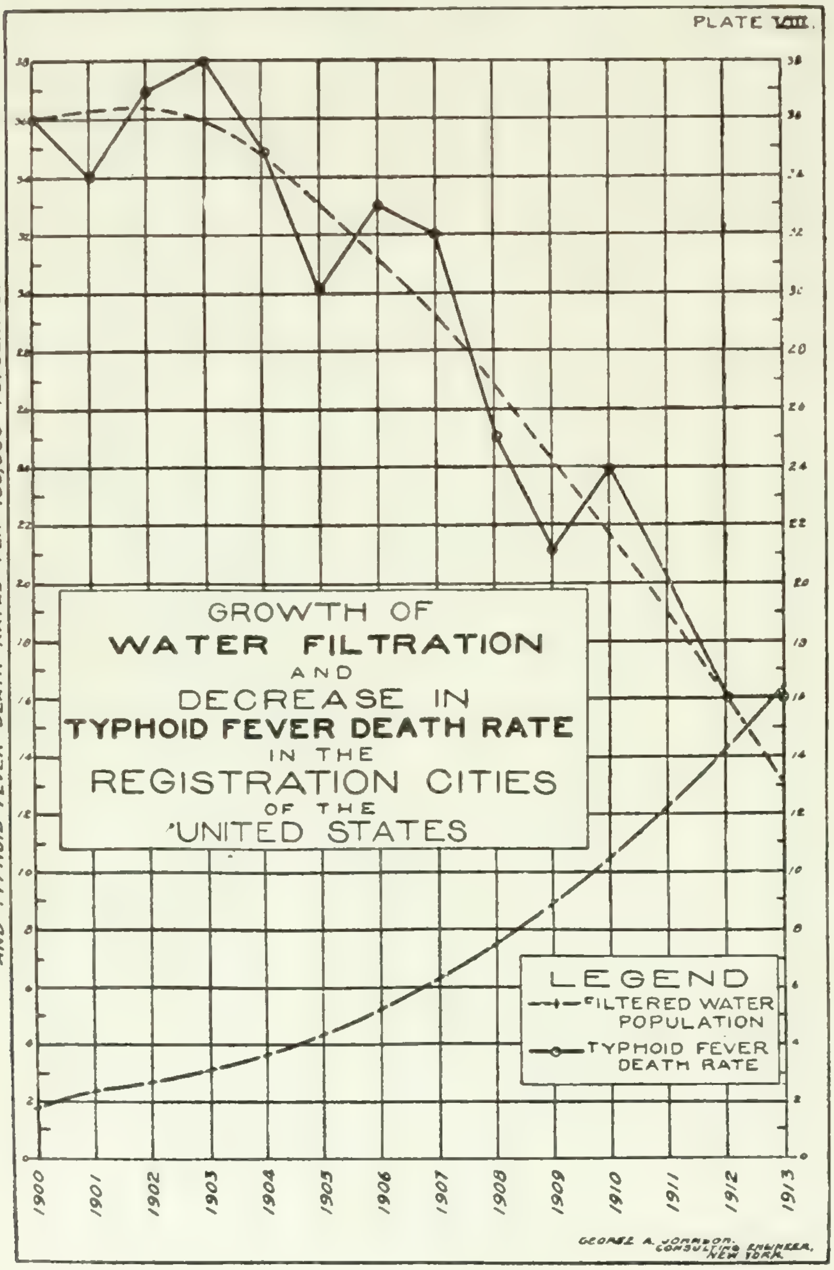
Laws have been enacted giving to the state the power to force the purification of public water supplies within their boundaries. The so-called Bense Act of Ohio is one of these. There is need of more legislation of this kind, which leads to the protection of the public against itself. Such power, placed in competent hands, and with sufficient funds to enforce it, cannot but do immeasurable good. Too much reliance is put in moral suasion in such matters nowadays. The money can always be found if it has to be found, and many a man has put off the urgently necessary visit to the dentist because of the physical pain incident to such a visit and the strain on his pocketbook; but he is always happy and satisfied when it is all over.

It is precisely so with forced expenditures of public money for water purification. The thinking citizen realizes that he is taking a chance with disease every time he drinks a glass of contaminated city water, and yet is ready with excuses, chiefly of a financial nature, for not helping along the campaign for pure water; but no matter what he finally is compelled to pay for it, when he realizes how he has been benefited he is perfectly satisfied, even though for a time he is obliged to go without new paving in front of his house, apologize to visitors for his antiquated city hall, or something of the sort.

Contaminated Wells.—The excreta of typhoid sufferers always should be thoroughly disinfected, but the cases are very numerous where it is either not done at all, because of the unpleasant labor involved, or done in

a perfunctory manner. Where there is no water carriage system of sewerage these infected discharges are emptied in the privy or some other convenient place, sometimes being covered with earth, but more often not, and from these deposits, where favorable geological and topographical conditions obtain, the typhoid germ easily finds its way through or over the ground into nearby wells, which serve as sources of drinking water for one or more families.

The attendants on a typhoid sufferer not infrequently regard the urine of such a patient as innocuous, and since



it is less trouble it is emptied into a nearby sink or out of a back window. It has been positively demonstrated that the urine of a typhoid patient may contain as high as 1 to 500,000,000 typhoid germs per cubic centimeter, or from 5 to 25,000,000 in a single drop, and this is sufficient to show its very dangerous character, particularly in the contamination of dug wells.

A summary of the results of a large number of examinations made of wells located on farms in eastern and western United States showed that at least 60 per cent. of the wells examined were contaminated with bacteria which are always identified with sewage. There is no doubt that a fair share of the annual typhoid grist comes from the consumption of polluted well waters, either through direct consumption, or through the contamination of milk and other foods which are brought in contact with them.

Wholesale Pollution of Public Water Supplies.—Where the house of the typhoid sufferer is provided with a convenient water closet, the temptation is great for the attendant to eschew the disagreeable task of effective disinfection, and the excreta, without such treatment, are summarily dumped therein to find unimpeded transit facilities to the nearest waterway, from which others draw their water supplies. It may be that the sewage of such communities is subjected to some form of purification before it is allowed to flow into the nearest waterway, but no form of treatment used in any part of the world at all times actually destroys all of the disease germs in such sewages. It remains for those communities whose water supplies are thus polluted to purify them before consumption. If this is carefully done, all is well; if not, then there is always a heavy endemic toll of typhoid fever in those communities, the sodden monotony of which frequently is broken by a spectacular epidemic.

Death Rate.—Dr. Allen W. Freeman, Assistant Commissioner of Health of Virginia, recently said:—*

> We have learned by sad experience that the measure of typhoid fever in any community is the measure of the distribution of human filth in that community, and that the dissemination of human excrement will inevitably result in the spread of typhoid fever. . . . The problem is no longer an investigative or scientific problem, but a problem of administration. When the people of the United States wish to pay for absolute protection against typhoid fever it can be bought with the full assurance that the goods can be delivered. As physicians and sanitarians, we are most interested in the practical question, can typhoid fever be prevented? We know that it can. We know that our methods are certain, that they will yield the desired result in every case where they are properly applied. The problem remaining for solution is how to convince the American people that protection from typhoid fever is something worth spending money for.

Dr. Freeman estimates that in the northern part of the United States the purification of all water supplies would result in the reduction of the annual typhoid rate to a figure usually less than twenty per hundred thousand population, while in the south the purification of the water supply alone would seldom reduce the rate to less than fifty per hundred thousand, other measures, such as perfect sewering or rigid screening and supervision of dry closets, being required to bring down the rate to the point which could be reached in the north by water purification alone. Below this point, in the north and south alike, reduction must be attained by the thorough super-

*The Present Status of our Knowledge Regarding the Transmission of Typhoid Fever, Public Health Reports, issued by the United States Public Health Service, January 10, 1913.

vision of cases of illness, which means the requirement of morbidity returns and the prompt notification of all suspicious cases, protection of milk and other foods from typhoid contamination, elimination of flies and their breeding-places, control of typhoid carriers, and the use of anti-typhoid vaccine wherever feasible.

Dr. Freeman's viewpoint is unquestionably sound, but in the broad analysis his estimates of what filtration would do are perhaps a little too low. For years it has been recognized that efficient filtration of the public water supply of a community will result in a reduction of from two-thirds to three-quarters in the typhoid fever death rate. Where the initial rate is high the percentage reduction following filtration of the water supply usually is correspondingly high, as noted particularly in the cities of Albany, Cincinnati, Columbus, Lawrence, Philadelphia and Pittsburgh. In these cities the average typhoid fever death rate for the five-year periods before and after filtration, respectively, showed a reduction of 76 per cent., or a typhoid fever death rate per 100,000 population of seventy-nine reduced to nineteen. The combined result of water filtration in twenty representative cities showed that filtration was followed by an average reduction in the typhoid fever death rate of 65 per cent.

Table 16.

Reduction in typhoid fever death rates in American cities following the filtration of their public water supplies (averages for five years before and five years after filtration):—

City	Average Typhoid Fever Death Rate — Before Filtration	After Filtration	Per cent. reduction in Typhoid Fever Death Rates which followed the filtration of the Public Water Supply
Albany, N.Y.	109	28	74
Charleston, S.C.	106	62	41
Cincinnati, O.	56	11	80
Columbus, O.	83	17	78
Harrisburg, Pa.	72	33	54
Hoboken, N.J.	18	13	28
Indianapolis, Ind.	46	28	39
Lawrence, Mass.	110	23	79
Louisville, Ky.	57	24	58
New Haven, Conn.	40	25	38
New Orleans, La.	39	26	33
Paterson, N.J.	29	9	69
Philadelphia, Pa.	63	20	68
Pittsburgh, Pa.	132	19	85
Providence, R.I.	19	13	31
Reading, Pa.	53	35	34
Scranton, Pa.	25	10	60
Springfield, Mass.	22	22	0
Washington, D.C.	55	31	43
Wilmington, Del.	35	24	31
Weighted averages	60	21	65

Among sanitarians there appears to be little, if any, dissension from the view that modern filtration practices actually eliminate the water-borne diseases, or typhoid fever and allied disorders at the very least. That is to say, where the plants are properly designed, well constructed, and intelligently operated, water filtration, in practical terms, is one hundred per cent. hygienically efficient.

Table 17.

Relationship between the increase in population supplied with filtered water and the decrease in the typhoid fever death rate in the registration cities of the United States:—

Year	Populations — Total for registration cities	Total in United States supplied with filtered water	Per cent. which filtered water population was of — Total population of United States	Total population registration cities	Typhoid fever death rate in registration cities
1900	21,477,000	1,860,000	2.4	8.7	36
1	22,146,000	2,400,000	3.1	10.8	34
2	22,679,000	2,700,000	3.4	11.9	37
3	23,221,000	3,100,000	3.8	13.3	38
4	23,724,000	3,800,000	4.6	16.0	35
5	24,729,000	4,300,000	5.1	17.4	30
6	26,342,000	5,400,000	6.7	20.5	33
7	27,145,000	6,300,000	7.2	23.2	32
8	28,501,000	7,500,000	8.4	23.3	25
9	29,655,000	8,900,000	9.8	30.1	21
1910	21,342,000	10,805,000	11.7	34.6	24
11	32,376,000	12,000,000	12.8	37.2	20
12	33,304,000	14,100,000	14.7	42.4	16
13	34,230,000	16,500,000	17.0	48.0	16

In Table 17 and Plate VIII. some instructive statistics are presented to show how the urban typhoid fever death rate has been reduced as water filtration developed. The relationship between the two is strikingly proportional, and holds out every good promise for the future.

FIRE PROTECTION ON RAILWAYS.

The Board of Railway Commissioners' Fire Inspection Department issued orders recently, under general order 107, directing the C.P.R., the Canadian Northern Railway and the Grand Trunk Pacific Railway to maintain a sufficient force of fire rangers for efficient patrol and fire fighting duty on their lines, between April 1 and November 1, except in so far as they may be relieved from so doing by an order in writing from an authorized officer of the Board. The directions of the order are specific in each case, and the areas within which the patrols are to be maintained are fully set out. The directions to the C.P.R. cover mileages on the Manitoba, Alberta and British Columbia Divisions; to the Canadian Northern Railway, mileages on the Central Division, and to the Grand Trunk Pacific Railway, mileages on the Mountain Division. For the supervision of the work, the Board has appointed inspectors, located as follows: E. J. Zavitz, Toronto; Thos. McNaughton, Prince Albert, Sask.; P. C. B. Hervey, Edmonton, Alta.; E. H. Finlayson, Calgary, Alta.; D. R. Cameron, Kamloops, B.C.; M. A. Grainger, Victoria, B.C.; H. S. Irwin, Prince Rupert, B.C.; R. E. Allen, Hazelton, B.C.; H. G. Marvin, South Fort George, B.C., and P. S. Bonney, Tete Jaune, B.C. The object sought to be obtained is the prevention of fires along railways, and to avoid as far as possible the imposition of unnecessary expenditure upon the companies for that purpose. An efficient system of fire patrol can be established at a minimum expenditure, and as the conditions vary from time to time and from place to place, the fire inspectors appointed by the Board have authority to waive the requirements wholly or in part from time to time as practicable. The order in each case calls for the minimum of adequate protection.

COAST TO COAST

Milverton, Ont.—On May 18th Hydro-Electric power was turned on here for the first time. The system is part of an extension from Stratford, taking in the towns of Milverton, Listowel, Palmerston and Harriston.

Calgary, Alta.—Assistant City Engineer Sidenius reports that the second main arch of the Centre Street bridge will be finished this week. This leaves only one more arch to complete. The bridge will be completed late in the fall, it is thought. There has been some little delay in the work in connection with the big fill on the north side. Earthwork cannot be commenced until frost is out, but the engineers hope to be able to start on June 1. There are 110,000 yards of earth still to be handled.

Ottawa, Ont.—The government bill providing for the purchase of the Quebec & Saguenay Railway, the Quebec & Montmorency and the Lotbiniere & Megantic Railways, passed the House of Commons last week. The government's proposal provides for the fixing of the price which is to be paid for the Quebec & Saguenay by the arbitration of the Exchequer Court. The value is to be the actual cost of the road less depreciation, but not to exceed $4,465,000. In addition, the government is to assume the bonded indebtedness of the Quebec & Montmorency, the electric end of the system, but not exceeding in all $2,500,000.

The Pas, Man.—Steel-laying has been resumed on the last half of the Hudson Bay Railway on the 90-mile stretch between Manitou Rapids and Kettle Rapids. The construction company says the track will be at the Kettle Rapids by August 1, where further advance will be delayed pending the erection of an 1,100-foot girder bridge over the Nelson River. In any event the contractors are sure to have the steel track laid into Port Nelson by next summer at the latest.

Ottawa, Ont.—There is a likelihood that Dr. J. S. Plaskett will be appointed chief astronomer for the Dominion. He is in charge of the new observatory at Victoria, B.C., where was installed recently the largest telescope of its kind in the world. Dr. Plaskett went to Victoria from the staff at Ottawa. The proposal is to keep Dr. Plaskett at Victoria on account of the fact that the observatory there is now the most important one in Canada. In that case, Dr. Otta J. Klotz will be placed in charge of the observatory at Ottawa, which he virtually has been since the death of Dr. King.

Toronto, Ont.—A. D. MacTier, general manager, eastern lines of the Canadian Pacific Railway Company, has announced that the new North Toronto station will be ready for use in June.

Dundas, Ont.—The formal opening of the public utilities commission's new offices took place on May 9th. The building is of red brick and was erected by the Dickson Building Company.

Victoria, B.C.—A number of new works were approved by the city council recently. One was the placing of a quantity of rock before the Ross Bay seawall, thus affording it extra protection. For this an appropriation of $6,000 was ordered. For necessary work on Douglas Street a $1,000 vote was authorized. It was decided also to make some repairs to the James Bay Causeway landing, and for this purpose the expenditure of $250 was approved.

St. John, N.B.—The city of St. John, N.B., has adopted as standard time that of the forty-fifth meridian, one hour faster than that of the sixtieth meridian, which heretofore has been used. This change is made at this time with a view to making it easy for everybody to adjust his day's work so as to get into it the maximum number of hours of daylight. The Canadian Pacific, which runs to St. John, uses, at present, Eastern Standard time, hitherto one hour slower than the time used in the city; and now, unless it changes, the road's clocks will be two hours slower than those showing city time.

Calgary, Alta.—The one-year power agreement between the city of Calgary and the Calgary Power Company for power needed above 5,000 horse-power has expired. The city is now taking only 5,000 horse-power from the power company, and power needed over and above this amount is being generated at the city power-house. Gas is being used at the present time as fuel. Power Engineer J. F. McCall has recommended that the agreement be not entered into this year, believing it to be a better policy for the city to use its million-dollar power plant to develop any power needed above the 5,000 horse-power maximum contracted supply.

Ottawa, Ont.—The revised plans for the new Parliament Buildings carry out the present architectural design, and, as a matter of fact, are in accord with the original design for the building, which contemplated four stories instead of three. No change is made in the plans for the interior grouping of offices, Commons and Senate chambers, etc., as submitted in the architects' plans of a month or so ago. The new upper story will be devoted to restaurant accommodation and additional rooms for the members. From the architectural standpoint the raising of the building is an improvement, according to the architects. The additional cost is estimated at something over $1,000,000.

Listowel, Ont.—Hydro power was turned on for the first time on May 28th.

Sarnia, Ont.—The city of Sarnia has taken over the power plant and lines of the local electric company, and will operate it until Niagara power arrives in a couple of months. The plant will be changed from a 60-cycle power to 25 as soon as the Hydro arrives. The Hydro transmission line is now nearing Sarnia.

Montreal, Que.—The new subway on Park Avenue at the corner of Van Horne Avenue, actual construction on which was commenced on May 6, 1915, has been opened for traffic purposes. Laurin and Leitch were the contractors, the price being $176,000. Seven separate tracks of the C.P.R. run over the subway bridge, which is 80 feet wide, 900 feet long and 17 feet 5 inches from the ground. While authorization was given for the construction of the subway in 1909, it was the winter of 1914-1915 before the work of diverting sewers was commenced.

South Vancouver, B.C.—The George Street sewer will be completed in the early part of June. It is also expected that the laterals in Wards 3 and 4 will be completed by the end of June.

Ottawa, Ont.—Hon. F. G. Macdiarmid, Provincial Minister of Public Works, Toronto, has instructed a survey to be made shortly of the proposed Ottawa-Prescott highway, approximately 60 miles in extent. After the survey has been made and all the data collected it is likely that a commission will be appointed, the highway declared a main road, and come under general legislation.

Angus, Ont.—Col. Low, who has charge of the construction at Camp Borden, informed the Militia Department that he has struck another gusher flow of water of over half a million gallons per day pouring out of a two-foot pipe. This ensures a magnificent water supply.

Editorial

THE FLUXING OF ASPHALT.

In an early edition of *The Canadian Engineer* there will appear an article, by a well-known authority, explaining how asphalt can be easily fluxed to any desired penetration.

It is generally recognized that any properly refined asphalt, whatever may be its penetration, can be brought to any given higher penetration without difficulty and without doing any harm whatever to the asphalt, provided that a true asphaltic flux is added. It is apparent, however, that all municipal engineers in Canada do not yet realize this fact, because one Canadian city recently paid $7,900 for 300 tons of fluxed asphalt of about 60 penetration, when they were offered an exactly similar asphalt, of 47 penetration, for $5,800. By doing the fluxing themselves, the city could have saved upwards of $2,000. But the city refused to consider any unfluxed material.

Incidentally, the specification issued by this particular city merely mentioned "refined asphalt" and did not call solely for fluxed asphalt. Nor was the required penetration stated anywhere in the specification, so that it was, to a certain extent, guess-work for any firm to bid on a fluxed material, not knowing to what penetration it would have to be fluxed. Moreover, no specification was issued defining the fluxing material to be used, thus allowing the possible use of light paraffin oils.

In view of incidents of this nature, we feel that an article reviewing the entire situation as regards fluxes and fluxing, will be of general use and interest.

PREVENTION OF TYPHOID.

At the convention of the American Waterworks Association, which is still in session in New York City as we go to press, a noteworthy paper entitled "The Typhoid Toll" was read by Mr. George A. Johnson, consulting engineer, New York. While it is impossible to print the paper in its entirety, we have in this issue reproduced such portions of it as are of particular interest to readers of *The Canadian Engineer.* From this extract it will perhaps be possible for our readers to realize with what care and thoroughness Mr. Johnson has gone into his subject.

Municipal engineers, especially those directly in charge of water supply, very frequently have to expend a great deal of effort to convince civic authorities of the economic waste resulting from impure water. The statistics which Mr. Johnson has produced and placed in proper sequence are most impressive, and should be quite sufficient to convince those who are responsible for the appropriation of monies for waterworks construction and maintenance, that typhoid fever, which is altogether too common in many of our communities, can be successfully prevented.

The results of water purification, as Mr. Johnson most convincingly shows, always give a large balance on the right side of the ledger. Where one dollar is spent for pure water, many dollars are saved in the form of vital capital through the prevention of sickness and death.

MONTREAL AQUEDUCT SCHEME APPROVED.

After the developments of the past three weeks, it is very unlikely that any change will be made in the Montreal aqueduct scheme.

On May 26th Controller Cote, who has charge of the Montreal works department, seemed partially to admit the need of some outside opinion being brought to bear upon the undertaking. He gave notice that on May 29th he would introduce a motion to appoint J. G. Sullivan and M. J. Butler as consulting engineers to advise Mr. Mercier *whenever their advice might be needed.*

When the time for his motion arrived, however, the controller failed to make it, and instead introduced to the Board of Control G. W. Fuller and J. M. Gregory, consulting engineers of New York City. According to newspaper reports, these gentlemen advised the controllers that the aqueduct scheme is a feasible commercial undertaking, and that the completion of the work should be left entirely in the hands of the city's engineers.

After several days of discussion, Mr. Cote withdrew his motion, and then Controller Villeneuve moved that Mr. Sullivan and A. St. Laurent be invited *to report upon the whole project.* As only Controller Ross supported him, the motion was defeated 3 to 2.

There are many very able men in the Montreal city engineering department, particularly the chief engineer. But they have inherited a scheme to which birth was given by their predecessors, and having become foster-fathers to the undertaking, they have assumed—perhaps unwisely—full responsibility for their adoption. Considering the large amount involved, and the heavy capital expenditures per expected horse-power, it would have been desirable for the Montreal board to have passed Controller Villeneuve's motion.

Messrs. Fuller and Gregory must have information not available to the general public, otherwise engineers of their repute surely would not have declared that the scheme is commercially feasible. Their O.K. upon the work and the plans has apparently ended the matter. Montreal must now sit back and pull straws to determine whether it is headed toward bankruptcy or toward prosperity effected through savings in light and power bills. After all, it's only the twentieth century and there's lots of time left yet for Montreal's government to progress!

SOO CANAL LOSES TRAFFIC.

Chiefly because the United States has constructed a large lock at Sault Ste. Marie, traffic through the canals of Canada last year decreased 58.9 per cent. In 1914, the traffic totalled 37,023,237 tons and in 1915, only 15,198,803 tons. The Sault Ste. Marie situation was responsible for 91 per cent. of the decrease.

In his annual report on canals, just published, Mr. J. L. Payne, comptroller of statistics, department of railways, Ottawa, points out that of the decline of 19,848,227 tons at the Soo, 1,049,241 tons were in Canadian boats and 18,798,986 tons in United States boats.

This meant a loss to the Canadian canal of 5.1 per cent. of the Canadian traffic and 94.9 per cent. of the

United States traffic. The cause of these losses was the that the new lock on the United States side has a much larger capacity than the lock on the Canadian side.

There are now three locks on the United States side of the St. Mary's River, the last to be opened having a depth of 24.5 feet at extreme low water. There is but one lock on the Canadian side, with a minimum depth of 18.25 feet. The ease of navigating the heavier loads through the new United States lock drew nearly all the iron ore and a good deal of wheat away from the Canadian canal.

PERSONAL.

R. H. BRAND, C.M.G., has been appointed an additional member of the Imperial Munitions Board, to act as the representative of the board in London.

T. A. JARDINE FORRESTER, city waterworks engineer, has resigned, having received orders from England to return home to rejoin his regiment for active service.

THOS. MAXWELL FYSHE, A.M.Can.Soc.C.E., a prominent contractor of Calgary, Alta., has become Canadian manager for Gunn, Richards & Company, production engineers.

H. VICTOR BRAYLEY, C.E., has resigned as Canadian manager for Gunn, Richards & Co., to accept a position as executive assistant to Mortimer B. Davis, a prominent Montreal manufacturer and capitalist.

Sapper NATHANIEL A. BURWASH, 6th Brigade, Canadian Engineers, who has been reported among the list of wounded, was born in Cobourg, Ont., and graduated at Toronto University in Mining and Engineering.

Lieut.-Col. C. H. MITCHELL, of the general staff, and Major THOS. C. IRVING, of the Canadian Engineers, were among those who received birthday honors conferred by King George last week, both of them receiving the D.S.O.

STANLEY H. ROSE, until recently in charge of the New York office of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, has been engaged by the Barber Asphalt Paving Company to direct its foreign trade department.

G. S. KELLEY, formerly with the Digger Machinery Co., Inc., has recently been appointed sales representative of the John F. Allen Co., of New York City, in connection with the new department they have established for the manufacture of coal-handling and hoisting machinery.

W. J. RENIX, district master mechanic of the Canadian Pacific Railway at Revelstoke, B.C., has been appointed master mechanic of the Saskatchewan division, with headquarters at Moose Jaw, Sask. He is succeeded by A. BROWN, formerly district master mechanic at Winnipeg, Man., who in turn is succeeded by G. TWIST, locomotive fireman at Fort William, Ont.

OBITUARY.

Major NORMAN C. PILCHER, whose death in action was recently announced, was formerly general manager of the Sherbrooke Railway and Power Company.

A. N. MUNGALL, civil engineer, who was engaged in the construction of the National Transcontinental and other lines, died recently at his home in Fredericton, N.B., at the age of 28 years.

HUGH F. COYLE, formerly superintendent of the Belleville division of the Grand Trunk Railway, and later general superintendent, died suddenly last week in his private car while returning home from a visit to his son at Meadville, Penn.

SIMPSON FLEMING, who died in Ottawa recently at the age of 89 years, was the first superintendent of the Ottawa waterworks, and constructed the first system of mains to be laid. He served with both City Engineers Keefer and Surtees, and held his waterworks position for 30 years, retiring 15 years ago. His advice was frequently sought since on waterworks matters, and he went to Arnprior for a time to conduct an inspection of the waterworks system there. The late Mr. Fleming came to Canada when 20 years of age from County Armagh, Ireland.

ENGINEERS' CLUB OF MONTREAL.

The Engineers' Club of Montreal shows a most prosperous financial statement for the year ending March 31, 1916, with net profits of $12,805. The profits were applied to writing off portions of the general equipment account, furniture and fixtures account, etc., from 20 per cent. to 33⅓ per cent. being written off each account. The club now has assets totaling $281,000, and a surplus of assets over liabilities of $91,000.

There are 515 members on the roll, including 19 who are on active military service overseas. Four members were killed in action during the year, namely, Major J. N. Warminton, Lieut. W. C. Brotherhood, Lieut. A. F. Revol and Major Geo. Janin.

Henry Holgate is president of the club and R. W. H. Smith, secretary. The executive committee consists of Lawford Grant, J. M. Miller, John C. Russell, Julian C. Smith, R. M. Wilson, Leslie H. Boyd and E. Herb. Brown. The statement speaks very well for the support that the engineers have given to the club during the past year.

ENGINEERS' CLUB OF THOROLD.

The Engineers' Club of Thorold is the name of a new organization, the purpose of which is to bring together in a social and professional manner the numerous members of the Welland Ship Canal engineering and contracting staff, on all the sections, and prominent residents of Thorold and St. Catharines whose business associates them with the engineering profession. The club has secured suitable quarters at 55 Chappel Street, Thorold, which have been newly decorated and furnished throughout, and a steward is employed at the club for the furnishing of meals. It also provides lodging for members. The membership of the club is about 70, the officers being as follows: Honorary president, Mr. J. L. Weller, engineer-in-charge, Welland Ship Canal, St. Catharines; president, Mr. E. G. Cameron, resident engineer, Section No. 3, Thorold; vice-president, Mr. F. H. Keefer, K.C., Canadian counsel for International Joint Commission; secretary, Mr. H. L. Clifford, assistant resident engineer, Section No. 3, Thorold; treasurer, Mr. J. A. Elliott, manager, Royal Bank, Thorold.

It is proposed from time to time to have papers presented to the club which would be of interest to members of the engineering profession.

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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

WATER POWERS ON THE WINNIPEG RIVER

POSSIBLE COMMERCIAL OUTPUT OF RIVER CONSIDERABLY EXCEEDS HALF MILLION HORSE-POWER—MINIMUM FLOW OF TWENTY THOUSAND SECOND-FEET OBTAINABLE AT ALL SEASONS—REVIEW OF REPORT BY DOMINION WATER POWER BRANCH.

WHILE Canada is endowed with a great natural resource in its water powers, a very small percentage of the total power available has been so far developed and used. But in the development that has taken place, Canadian financiers by their foresight; Canadian engineers by their skill; and Canadian government officials by their co-operation, have blazed a trail that can be equalled by few other countries, and surpassed by none.

It has only been in recent years that Canadians have wakened to the knowledge of the tremendous natural advantages that Canada has in her extensive and fortunately located water powers. In most provinces of the Dominion, this awakening has resulted in a sincere and successful endeavor to become fully informed of all aspects of the water power situation, in order that proper provision should be made for investigation, administration and ultimate development.

There is no part of the Dominion where the advantages and opportunities of water power are more appreciated than in the provinces of Manitoba, Saskatchewan and Alberta. In this territory the water powers are administered by the Department of the Interior through the Dominion Water Power Branch, which branch has, since its organization eight years ago, made thorough reconnaissance investigations of all the water powers in the present settled portions of the prairie provinces, and most of the water powers on the more important rivers in the hinterland. On some of the rivers close to existing commercial centres, such as the Bow River in the province of Alberta,* and the Winnipeg River in the province of Manitoba, it was early found necessary to have a thoroughly complete investigation made of the topographic and hydraulic features of the whole power situation.

Fig. 1.—Pinawa Channel, Winnipeg River.

Sixteen miles below Slave Falls the river is broken into two channels. The main flow is through the Seven Sisters reach. The lesser flow is through the Pinawa Channel, operating the Winnipeg Electric Railway Company's plant. This was formerly a high water by-pass of the main river. The illustration shows some of the rock cutting that was necessary to straighten and deepen this channel.

The most elaborate and extensive investigations that the Water Power Branch has carried on, have been continuously under way for over four years, under the immediate direction of J. T. Johnston, chief hydraulic engineer of the branch. A complete report of these investigations has just been issued, under the title of "Water Resources Paper No. 3." The results of the investigations are of great interest from engineering, industrial and economic standpoints.

The investigations show that it is possible to develop on the Winnipeg River, at 9 power sites, 420,000 continuous 24-hour horse-power. This is sufficient power to meet the ultimate requirements of the city of Winnipeg for many years to come.

The report on the Winnipeg River powers is unique in scope and arrangement. Every possible aspect of the power situation has been gone into carefully, and the results are tabulated in convenient form.

*Reference was made in *The Canadian Engineer*, issues of November 26th and December 3rd, 1914, to the investigations along the Bow River, which show conclusively that it is possible to develop at five sites on the Bow River, a total of 55,000 continuous 24-hour horse-power, and all within a very short distance (about sixty miles) of the city of Calgary.

Apart, however, from the report itself, the comprehensive scheme of development of the whole river, realizing the best possible use of the natural advantages of the river for power purposes, is so feasible, and of such importance to the West, that a liberal review of the power situation will undoubtedly be of general interest.

Winnipeg River Basin.—The basin of the Winnipeg River forms a portion of the Nelson River drainage system. The watershed is 53,500 square miles in area, of which 37,900 square miles lie in the province of Ontario, 4,600 square miles in the province of Manitoba and 11,000 square miles in the State of Minnesota. The basin is, therefore, international as well as interprovincial, and conflicting problems arise in connection with storage regulation in the upper reaches.

The upper waters are divided between two drainage systems, the English River draining the northerly 21,600 square miles, and the upper reaches of the Winnipeg draining the southerly 27,000 square miles. The entire watershed is very sparsely settled, and a large proportion offers little opportunity for agricultural settlement. The larger part of the basin consists of a forest-covered laurentian formation with much granite outcropping, and is interspersed with lakes and muskegs and occasional stretches of agricultural land. Practically the entire basin is seamed and dotted with lakes of every size, from mere ponds to the 1,500 square mile spread of the Lake of the Woods.

Situation at Beginning of Survey.—At the time when the power and storage investigations along the Winnipeg River were instituted by J. B. Challies, superintendent of the Dominion Water Power Branch, the hydro-electric plant of the Winnipeg Electric Railway Co. was in operation on the river, and the initial installation of the Winnipeg municipal plant was approaching completion.

The Winnipeg Electric Railway Co.'s plant is located on the Pinawa channel of the Winnipeg River, about 58 miles from Winnipeg, and has installed a total turbine capacity of 34,000 h.p. This, in conjunction with the 22,000-h.p. steam turbine plant in the city, supplies power for distribution in Winnipeg.

The city of Winnipeg in 1908 began the construction of a municipally owned power plant at Point du Bois, on the Winnipeg River, distant 75 miles from the city, and at the time of the commencement of the survey, was completing the first turbine installation. Eight units with a total turbine capacity of 47,000 h.p. are installed to date, and additional bays are partially constructed to accommodate eight further units when the market demands. The power is transmitted to Winnipeg for general lighting, industrial and domestic use.

With the power from these two sites either developed or in course of development, the department was in receipt of numerous applications covering other sites along the river. It was, no doubt, realized that further hydro-electric development on the river was a matter of the im-

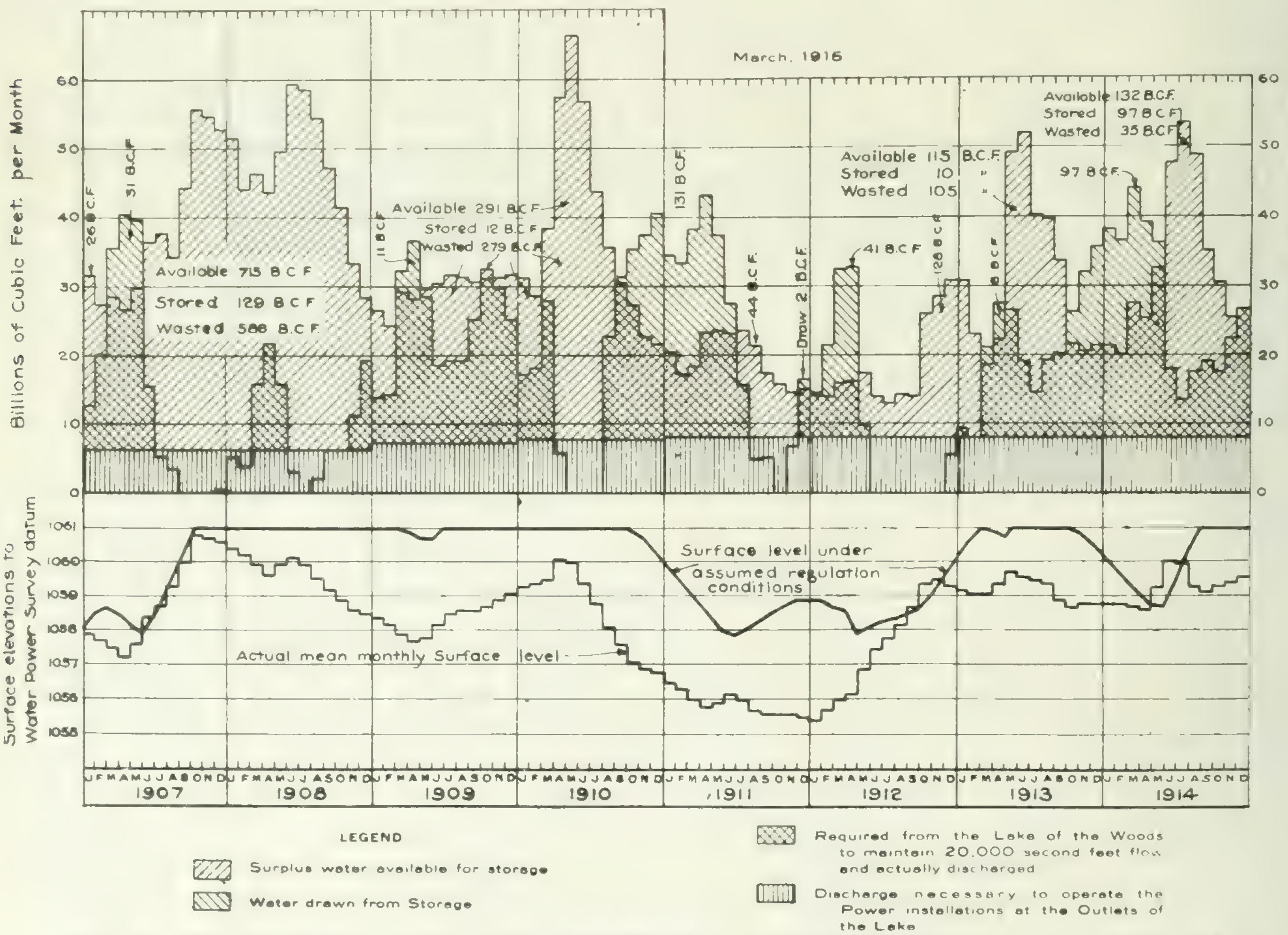


Fig. 2.—Mass Curve Study—Use of Lake of the Woods as a Regulating Reservoir, and the Effect of Such Regulation on the Surface Levels.

[NOTE: In this analysis it has been assumed that a minimum flow of 20,000 second feet is maintained throughout the power reach of the Winnipeg River in Manitoba, by means of regulations in the Lake of the Woods reservoir alone. At the same time sufficient water has been discharged at all times to operate properly the power installations at the lake outlets.]

mediate future, and that if a comprehensive policy were to be mapped out into which new developments could be incorporated as component units, there could be no delay in commencing the investigations. So, early in 1911 a survey party was placed in the field.

Scope of the Investigation.—It was intended that the investigation should be sufficiently extensive in scope to furnish the department with all information and data necessary to design a power scheme suitable for the development of the entire water resources of the river in the province of Manitoba. This necessitated extensive investigation into the storage resources of the upper watershed. The scope of the investigation was therefore outlined to include the following:—

A preliminary reconnaissance of the power reach; a continuous base profile; detailed contour surveys with soundings of all falls or rapids at which power concentration was possible; contour surveys of the river banks throughout the entire power reach; determination of the best points of concentration; design of power layouts for such locations; estimates of capital and operating costs of proposed plants; establishment of metering stations at strategic points; establishment of evaporation stations; study of existing rainfall and temperature records; investigation into the question of storage in the upper watershed; study of prior water rights and relative value and effect of same; comprehensive provision for future navigation; close study of all existing power plants and interests; study of present market conditions and future prospects; investigation into cost of power from coal, gas and oil; recommendations for the carrying out of an aggressive policy of development; and recommendations insuring government supervision over regulation, both in connection with individual power plants and of the storage conditions as a whole.

River Discharge.—Owing to the extensive forest cover and to the innumerable lakes throughout the watershed, the Winnipeg River is naturally one of the best-regulated rivers on the continent. In a normal year the flood flow seldom exceeds four times the minimum. Continuous discharge records are available at Slave Falls in Manitoba, at the outlets of the Lake of the Woods, and at Fort Frances, from the beginning of 1907 to date. Actual records over this period show a minimum flow of 11,700 and a maximum of 53,440 cubic feet per second in the power reach in Manitoba. Well-defined water marks along the shores would indicate that a flood of possibly 100,000 second-feet has taken place in the past.

While the natural regulation of the run-off is excellent, there are fine facilities for aiding nature by utilizing reservoir opportunities in the upper basin. Among these natural reservoirs might be listed: Lake of the Woods, 1,500 square miles in area; Rainy Lake, 330 square miles in area; Namakan Lake, 100 square miles in area, and Lac Seul, 340 square miles in area.

A review of the run-off records and a study of the storage opportunities warrants the conclusion that a systematically controlled regulation of the reservoirs in the upper watershed will increase the minimum dependable flow in the power reach to 20,000 cubic feet per second.

The splendid facilities of the Lake of the Woods as a storage reservoir are best illustrated by the mass curve, Fig. 2, in which an assumption is made that the lake had been so operated since 1907 (from which date discharge records are available) as to maintain a dependable flow of 20,000 second-feet in the power reach of the Winnipeg River in Manitoba, and at the same time maintain an outflow from the lake, at all times amply sufficient to meet the needs of the existing power developments at the lake outlets. The mass curve indicates that with systematic supervision, these ends could have been attained with a maximum change in the surface level of some 3.1 feet during the period, against a change of 5½ feet which has actually been experienced with the unsupervised regulation which has been maintained. It might also be noted that the cycle considered covers a prolonged period of exceptionally low run-off.

Field and Office Investigations.—In June, 1911,

Fig. 3.—Pine Falls, Site of Proposed Power Station.

Initial development proposed, 60,000 h.p.; final development, 100,000 h.p. Capital cost per h.p.—$50.95 for initial installation, $44.07 for complete installation.

active field work was commenced by running a continuous line of base levels, to sea level datum, from Lake Winnipeg to the Lake of the Woods. While this was under way a preliminary reconnaissance was made of the entire power reach and the necessary steps taken to continue systematic field studies. Actual contouring was commenced in September at Du Bonnet Falls and was thereafter continued systematically until the entire power reach was covered.

Detailed attention was given to all falls and rapids and possible points of power concentration. The survey work was plotted in the field to a scale of 400 feet to the inch, on standard sized sheets 30 by 37 inches, fifty-five sheets being necessary to cover the power reach from Lake Winnipeg to and including the pond of the Point du Bois plant. Detailed plans to a large scale were made of all important locations.

This immediate plotting on the ground was greatly aided by the loose-leaf field note books adopted throughout the work. Standard sized leather covers with 5 x 8-inch

[illegible] suitably printed and ruled for transit, stadia and level work were provided. The loose leaves lent themselves readily to a simple filing system on which the records of the survey were properly grouped and were at all times available for instant reference.

The finished tracings were forwarded to Ottawa as completed, where immediate study was given to the design of a comprehensive power system utilizing the river's possibilities to maximum advantage.

Upon the completion of the tentative study of the layouts, a further reconnaissance was made of the actual sites selected, and additional details as to rock surface, etc., were secured.

General Conclusions.—The general conclusions reached as a result of the entire investigation are that full realization of the power resources of the Winnipeg River in Manitoba is possible only through an exhaustive measure of run-off control, and feasible only through the establishment of storage reservoirs in the upper watershed. Due to the conflicting requirements of the lumber, fishing, navigation and power interests represented in the watershed, a proper run-off control satisfactory to all can best be insured by some central governmental authority possessing the full confidence of all interests affected, and having entire authority over all questions affecting lake, reservoir and pond levels, and over all questions of river flow and of discharge requirements.

This authority can only be properly exercised through government-owned or operated storage reservoirs. In conjunction with this control, full realization of the power resources of the Winnipeg River in Manitoba is only attainable by a power system in which each developed site forms a component link in a comprehensive scheme looking to the development of the entire river reach. Due to the interdependence of a series of hydro-electric plants, such as is proposed, and to the conflict of head and tailwater elevations, satisfactory operation can only be realized through an independent supervised control over local pond regulation. The full conservation of the power resources of the watershed requires also the institution throughout the watershed of a systematic policy looking to a proper preservation of the forest cover which now so effectively assists in the natural regulation of the river flow. Consistent steps to these ends have already been taken by the Dominion Water Power Branch.

In laying down a complete system of hydro-electric development for the power reach, two outstanding features compel first consideration, *i.e.*, the existence of the two hydro-electric undertakings of the Winnipeg Electric Railway Co., and of the city of Winnipeg, respectively. With these two plants already in existence, and after fully protecting their interests in all respects, it has been possible to divide the remainder of the river drop into seven concentrations for power development, having a total possible output of 175,000 continuous 24-hour horsepower available at 75 per cent. efficiency under the present unregulated minimum flow, and 313,000 continuous 24-hour horse-power available from the proposed 20,000 second-foot dependable minimum flow under regulated conditions.

Including the two existing developments, the total resources of the power reach at nine sites are 249,000 and 418,000 continuous 24-hour horse-power under the above respective conditions of flow.

As these totals are given in terms of 24-hour power, they give a rather limited estimate of the river's resources, particularly in view of the fact that each proposed plant has ample pondage facilities to handle any peak load which may be anticipated. What may be called commercial output might, therefore, be considered as very greatly in excess of the above figures.

[Note.—The reader's attention is called to the brief advance review of this report that was published in the June 1st, 1916, issue of *The Canadian Engineer*, containing some data to which the above is supplementary; also to the seven-page article in the February 12th, 1914, issue of *The Canadian Engineer*, in which was included a plan of the existing sites and possible sites on the Winnipeg river, a profile of the river, and views of the following falls: Seven Sisters, Second McArthur, Pine, Silver, and Grand du Bonnet.—Editor.]

TESTS OF FLAT SLAB CONSTRUCTION.

W. W. Pearse, city architect and superintendent of building of the city of Toronto, will co-operate with Prof. Peter Gillespie, of the University of Toronto, in conducting a test of the flat slab construction at the new Simpson warehouse, Toronto. The test will be quite extensive and will cost approximately $1,000. An endeavor will be made to determine accurately the stresses in the concrete and in the reinforcing steel.

The Simpson building is designed according to the Chicago by-law. The test will be completed in August, 1916, and later in the year a similar test will be conducted in connection with the new factory building for the T. Eaton Co., Toronto, which has been designed in accordance with the Philadelphia by-law. These two tests should give a most interesting series of comparable results.

SHIPBUILDING IN BRITISH COLUMBIA.

The British Columbia Legislature is considering a bill to aid the development of the shipbuilding and shipping industries in the province. Two schemes are embodied, one providing for assistance in the building of wooden ships, and the other a bonusing of cargoes taken from British Columbia ports for ten years after the conclusion of the war. A commission of three is to be appointed for the administration of the act, one of whom is to be the Minister of Finance, who will be unpaid, the other two being salaried. The scheme for providing financial assistance for shipbuilding covers advances to the extent of 55 per cent. of the value of the plant and of whatever ships may be built, and will be for a period to be determined by the commissioners, who will exercise considerable control over the construction and subsequent operations of vessels so built, which will remain under the commissioners' control in the same manner until the loans are repaid in full. The second form of assistance is designed to keep the vessels under the commissioners' control returning to British Columbia, to ensure an outlet for British Columbia products. It is proposed to grant a bonus of $5 a ton for ten years on all cargoes, based on the dead weight, taken from British Columbia ports. The administration of the act, when it becomes effective, will be almost solely under the Government control, as practically every act of the commissioners is subject to an order-in-council.

An immense amount of construction work is going on behind the French lines. All old highways are kept in perfect repair and thousands of miles of new roads are constructed. In the region called the Champagne Pouilleuse the road question was a particularly difficult one. Loads of stones were swallowed up without much effect. So logs are laid side by side and corduroy roads built. There are hundreds of miles of these corduroy roads and over them pass heavy artillery, motor trucks filled with shells and other large vehicles. In this district the military engineers have had to bore hundreds of wells, for good water is a rarity. To do this, gangs of professional well sinkers were selected from the mobilized soldiers, and the country is now covered with their cases.

SEWAGE TREATMENT STUDY FOR NIAGARA FALLS, ONTARIO.

By H. S. Philips, A.M.Can.Soc.C.E.,
Formerly Assistant Engineer, Sewer Dept., City of Toronto.

DURING the summer of 1915, the writer was loaned by the city of Toronto Works Department to the engineering staff of the International Joint Commission, for the purpose of assisting in sewage treatment and interceptor studies. The following notes regarding Niagara Falls, Ont., which are condensed from my report to the consulting sanitary engineer of the Commission, may be of interest to readers of *The Canadian Engineer*:—

The 1950 densities, as computed from present-day drainage areas, are greater than are warranted by the present characteristics of this city, but are intended to include provisions either for annexation of city area or for inland extensions of sewerage districts.

Water consumption records are available from the year 1896 to the present date, but until November, 1913, were based upon plunger displacement, and owing to breaks in counters and in other parts, the data are incomplete and unreliable. Detailed studies were, therefore, confined to records since November, 1913, when a Venturi meter was installed. These records show a total pumpage of 1,287 million U.S. gallons during 1914, which is equivalent to a daily average of 3.53 million gallons, and to a per capita consumption of 307 gallons per day.

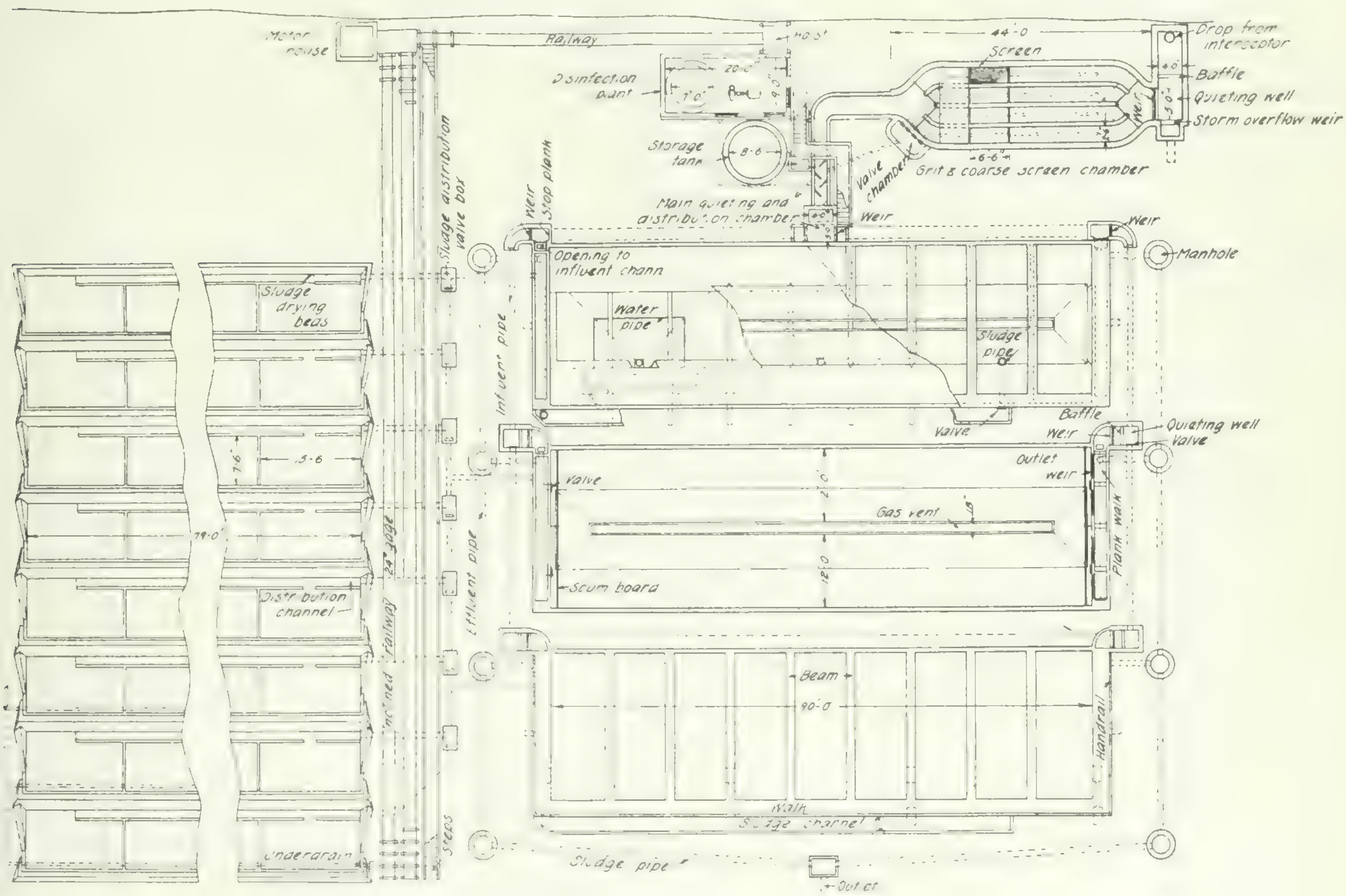


Fig. 1.—Niagara Falls, North End Imhoff Tank Plant.

The city of Niagara Falls, Ont., is located on the Niagara River, about one-fourth mile below the Horseshoe Falls. In addition to its character as a stopping point for tourists, the city is chiefly a hydro-electric power generating centre, though containing a few important industries.

The corporate limits include about 1,630 acres and extend 2.7 miles along the river. The river frontage is well built up with residences, but the major development of the city is centered in the northwesterly section.

Forecast of population has proceeded along two lines, including for collector design an increase paralleling that of the American city and adjacent territory. For treatment works figures the past performance of this city, together with percentage increases of Berlin, Guelph, and Brantford during corresponding periods of growth, have led to a population for 1930 of 18,000.

The figure of 307 gallons per capita daily may be expected to yield an average run-off of 95 per cent. of this figure, or 292 gallons per capita per day, the balance being an estimate of that portion of the total supply lost in lawn and street sprinkling and in processes of manufacture. The particular expression of the ratio has been obtained from studies made in Buffalo as modified to meet local conditions.

The application of the maximum rate of flow of 160 per cent. to the average rate of water consumption sewer discharge of 295 (292) gallons per capita daily gives a run-off of 467 gallons, or, as rounded off, 470 gallons per head per day, which is the figure that has been used for collector design.

For drainage purposes the city is at present divided into four districts, which are fairly well sewered. There

being four existing outlets, it is feasible to treat the sewage at four different sites, or else to collect from two or more outlets and carry to one or more disposal plants. From the administrative and operative point of view a single central plant is the preferable, but in the present instance the relatively low elevation of the Bender Street outlet would make very costly any collector to combine the sewage of this district with that from the balance of the city. Accordingly, it has been planned to treat the Bender Street sewage locally at works on the cliff side close to the present outlet.

The remaining outlets can be readily combined by means of an intercepting sewer, which would cost in the vicinity of $35,000. In other words, the expenditure of $35,000 would permit of the construction of one treatment works instead of three, and in addition to the consequent material saving in plant-construction costs would secure a lessening of labor charges due to the concentration and localization of the work. Also, the construction of an interceptor would harmonize with future sewerage development without additional construction, except for plant enlargement, whereas the subdivision scheme would necessitate either a new plant for each new outlet or else the construction of part of the collector proposed under the present plan.

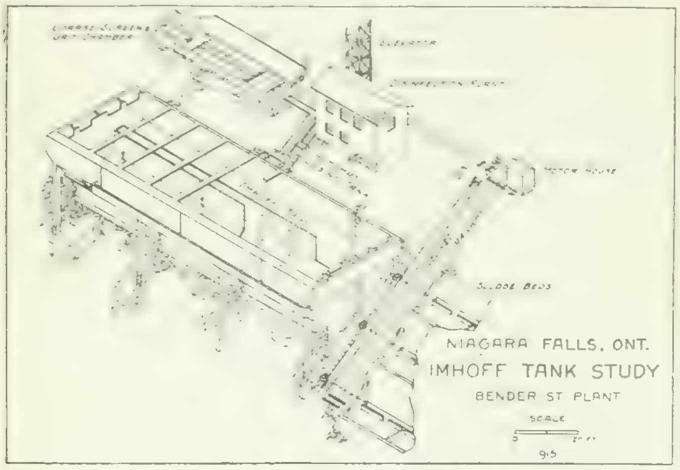


Fig. 2.—Bender Street Imhoff Tank Plant.

For these reasons treatment at one site is favored save in the case of the Bender Street sewage, as before noted.

A gorge side situation is at first sight objectionable from the point of expense and of difficulty of construction, but has been selected as more economic than inland sites requiring pumping, or than a northerly location which would require a long interceptor to secure gravity discharge. The gorge side topography consists of a slope of 40 degrees inclination extending from the river edge to a vertical cliff some 60 feet high. The foundation material is limestone, seamy but solid. At Bender Street the slope is covered with 5 or 6 feet of loose rock and boulders, but is bare at the northern site.

The land included within the Canadian gorge limits is under the jurisdiction of the Queen Victoria Park Commission, and inasmuch as the works proposed will in no wise mar the picturesqueness of the locality, it is probable that the use of area sufficient for disposal works can be secured without expense to the city.

The interceptor has been located on the River Road commencing at Seneca Street outlet and continuing to a drop shaft at Park Street, in order to avoid deep cutting; and thence to the outlet near Orchard Street, with a drop pipe to a treatment works located below the cliff.

Flat grades combined with a minimum velocity of 2½ feet per second have been used in the design of the interceptor. The velocity, while not so great as could be desired, is fairly conservative, and allows of the use of shallow cuts.

Treatment-works studies were followed with limitation to sedimentation and to fine screens, each coupled with disinfection by means of a solution of calcium hypochlorite.

In the case of tanks, the dimensions and proportions of the plants have been selected to give a sedimentation of two hours for an amount of sewage equivalent to 120 per cent. of the average flow.

Consideration of fine screens has been restricted to an installation for the North End plant because of the small flow to be treated at the southern plant. At the major works the 1930 average flow has been fixed at 7.7 cubic feet per second with a possible maximum of 23.4 cubic feet per second as the storm capacity of the interceptor. Upon commercial ratings, a 12-foot R-W screen, having one-sixteenth inch slots, is capable of passing 9.3 cubic feet per second with a 2-inch loss of head. With two such screens the available capacity is 18.6 cubic feet per second, or 80 per cent. of the maximum sewage flow.

The details of the two plants being similar, a general description will apply to both. As will appear from reference to Figs. 1 and 2, the features included consist of quieting well, grit and coarse screen chamber, disinfection plant, Imhoff tanks, and sludge-drying beds.

Wells with baffles have been placed at the outlet of the vertical portion of the interceptor to reduce the velocity and turbulence of flow. The baffle is of the underflow type, designed to prevent deposits. The wells are also provided with adjustable weirs at the side to permit of by-passing any desired portion of the storm flow.

The grit chambers have been designed to allow detention of the flow for 45 seconds with a velocity of 0.75 foot per second. The screen is of the usual inclined bar type with a 2-inch spacing.

The disinfection house has two floors, the lower of which contains the mixing well and machinery. The upper is a combined storage and charging floor equipped with a chain hoist and trolley to facilitate the handling of drums.

The bleach solution to the extent of 5 parts available chlorine per million of sewage is applied to the sewage as it leaves the grit chamber.

The sewage, after passing the dosing tank, reaches a central quieting and distribution chamber where the flow can be diverted to either end of the tank units by adjustment of the weirs. Quieting wells are also placed on the lateral influent lines at each tank.

The tanks upon which estimates have been based are of the Imhoff type, as modified by the requirements of the sloping ground at the sites. To meet the condition noted the lower compartment has been formed as half a rectangular pyramid.

Each tank unit as planned consists of two interconnected flow-through channels separated by a gas vent and designed to give a velocity of 0.0125 foot per second for 120 per cent. of the average flow. The sewage will enter through sluice-gate controlled orifices, and discharge over weirs at the farther end, the arrangement being such as to permit of reversal of flow to secure more uniform deposit of solids in the sludge compartment.

Removal of sludge is accomplished by gravity through vertical cast-iron pipes with horizontal valve-controlled connections to a concrete channel supported on brackets along the outer wall of the tank.

The sludge-drying beds are constructed in narrow terraces, partly in excavation and partly in rock fill. The drainage material is sand and gravel 15 inches thick. The beds are divided into stepped compartments by concrete partitions, and are provided with drains at the back of each retaining wall to carry off the effluent and to prevent seepage to the bed below.

The dried sludge will be removed from the beds in handbarrows and raised to the foot of the cliff in dump cars by a narrow-gauge inclined railway, which is double-tracked to allow the use of a counterbalancing car.

The North End fine screen plant, as designed, includes, in addition to the quieting well, grit chamber, and disinfection plant provisions, a screen house and disinfection channels. The common features are similar to those for the tank plant. The relative positions of the different parts are shown in Fig. 3.

The screen house is merely a covered extension of the sewage channel so formed as to receive two disk screens of the R-W type, with appropriate sluice gates, by-passes, and driving machinery. The screenings, as they are swept from the rotating screen plates, will fall through chutes into exterior storage pits, from which they can be removed to hopper cars and carried over a spur track to the elevator.

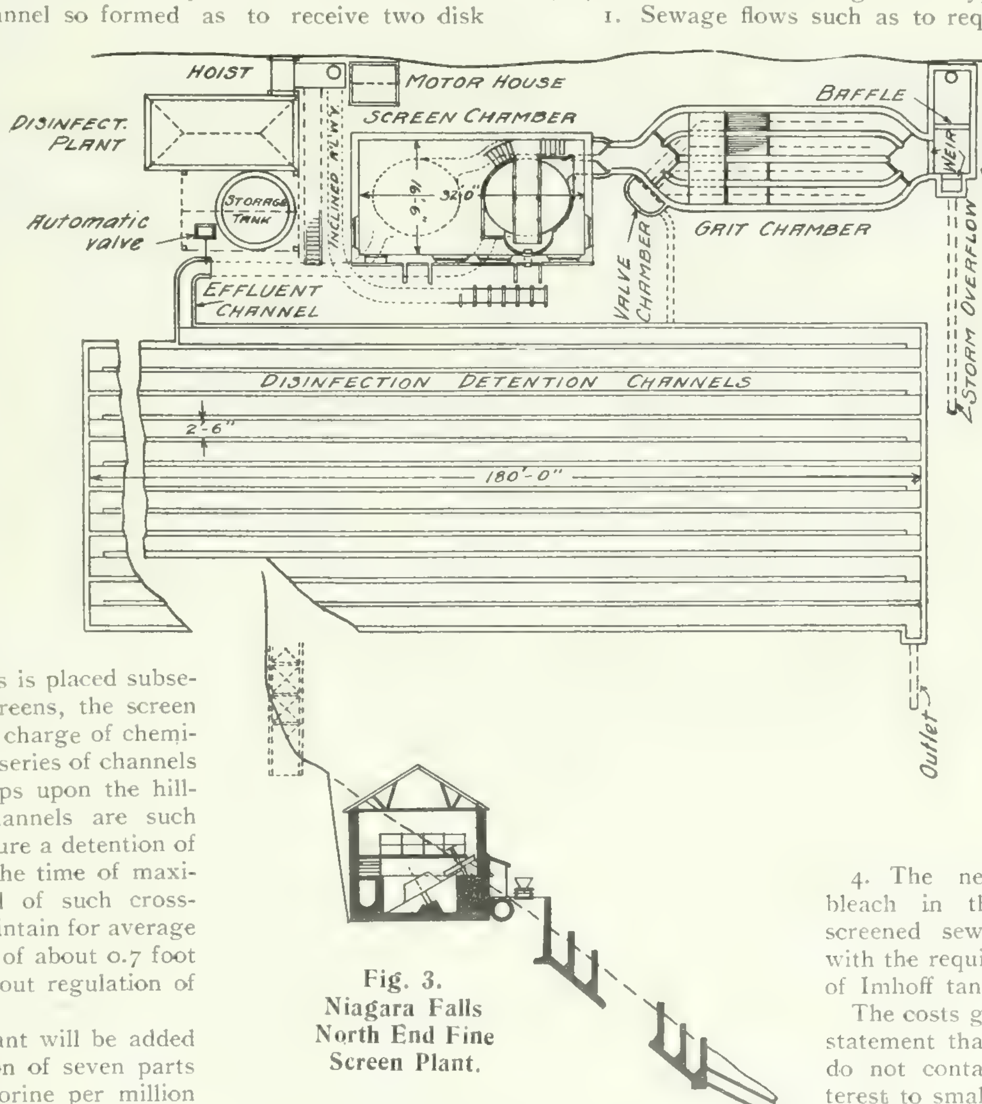


Fig. 3. Niagara Falls North End Fine Screen Plant.

As shown in Fig. 3, the disinfection process is placed subsequent to the screens, the screen effluent with its charge of chemical flowing to a series of channels arranged in steps upon the hillside. These channels are such length as to secure a detention of 15 minutes at the time of maximum flow, and of such cross-section as to maintain for average flows a velocity of about 0.7 foot per second without regulation of outlet gates.

The disinfectant will be added in the proportion of seven parts of available chlorine per million of sewage, equivalent normally to 175 pounds of bleach per million gallons.

The construction and maintenance costs of the different features of treatment were prepared in accordance with contract prices prevailing in Niagara Falls, and were as follows:—

Construction cost of interceptor $34,600
Construction cost of Imhoff tanks, Bender Street plant 14,853
Construction cost of Imhoff tanks, North End plant 34,184
Cost of fine screens, North End plant 46,950
Annual operation cost Imhoff tanks, Bender Street and North End plants 8,960
Annual operation cost, North End fine screen plant and Bender Street Imhoff tank plant 11,105
*Total annual charges, Imhoff tanks 14,068
*Total annual charges, fine screens 19,297

(In this connection, acknowledgment should be made of the assistance of Lieut. F. J. Anderson, B.A.Sc., formerly city engineer of Niagara Falls, Ont., who supplied the data upon which these studies were based.)

Treatment plants, including Imhoff tanks and disinfection, are thus shown more economic for Niagara Falls, Ontario, than those embodying fine screens. The differences are striking because the conditions are unfavorable to the installation of mechanical screens. The factors prejudical to a fair showing of this type of treatment are:

1. Sewage flows such as to require one fair-sized screen and for dry-weather discharge only one, but which, to sustain the maximum capacity of the interceptor and to provide reserve for the dry-weather unit, necessitates an additional screen, which serves to double this part of the plant cost.

2. The omission of any charges for the purchase of land, in which screens offer an economy.

3. The need for tanks or channels in which the full storm flow can be disinfected.

4. The need for additional bleach in the disinfection of screened sewage, as compared with the requirements in the case of Imhoff tanks.

The costs given strengthen the statement that fine-screen plants do not contain elements of interest to small towns, when it is desired to sterilize the effluent and when long outfalls for the latter purpose are not available. It should further be noted that the costs, as computed, do not make screens comparable with tanks, even in performance, for not only will the screens be overburdened during storm flows, but also at times of dry-weather flow the labor costs include

*Figuring interest at 4½%, eighty-year life for interceptors, fifty-year life for structures and fine screen machinery, and 10% combined amortization and repairs allowance for Imhoff tanks machinery.

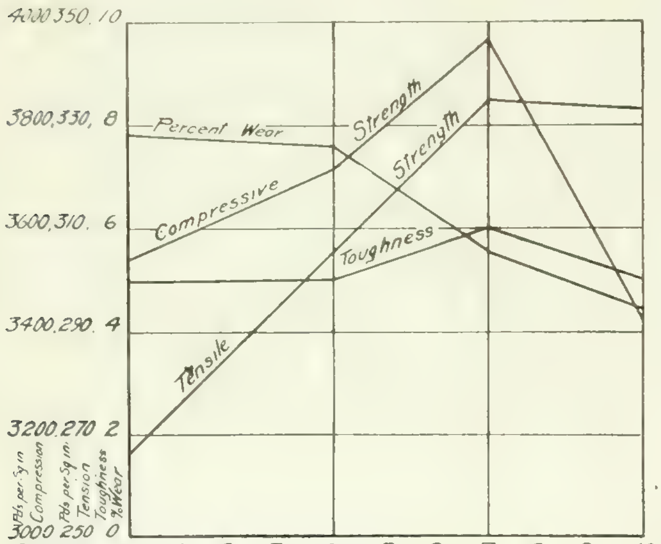
provision for but 10 or 18 hours' operation, upon the questionable hypothesis that the very low night flows can be neglected. In this respect the tank plants possess an advantage in the manner with which they can be left without attendance, though still in operation.

The finding of the report to the International Joint Commission is to the effect that the city of Niagara Falls, Ontario, can meet restriction upon the river discharge of crude sewage by the construction of Imhoff tank and disinfection treatment works at a first cost of $83,600 or less, and with annual labor and material charges of about $9,000.

HYDRATED LIME IN CONCRETE PAVEMENTS.

The use of hydrated lime in the construction of concrete pavements is a subject in which many of *The Canadian Engineer* readers are concerned. In the annual report on highway improvement in Ontario, G. Cameron Parker, B.A.Sc., assistant engineer, Department of Highways, Ontario, presents a report from which the following extracts have been taken:

That the addition of hydrated lime to concrete results in an increase in the waterproofing properties of the material has been recognized for a number of years. The problem of rendering the walls of concrete tanks, reservoirs and foundations has been solved in many cases by the use of this material.



Curves Showing Effect of Hydrated Lime in Portland Cement Mortar. (Mortar 1 : 2.)

Laboratory tests have shown that concrete containing hydrated lime not only becomes impermeable but that none of the desirable properties are sacrificed. On the contrary, increases in tensile and compressive strength have been recorded along with greater facility in trowelling and surfacing. Ordinary sand mortar does not lend itself to the obtaining of a smooth finished surface. When such is required a coating of neat cement or fine sand mortar, a cement wash, or handrubbing with abrasive blocks is usually resorted to. The lime appears to act after the nature of a flux, rendering the mortar smooth and plastic and making it possible to work up to a fine surface. The formation of surface cracks is lessened by the addition of lime, which indicates that it reduces the coefficient of expansion of the material, due to change in temperature and moisture content, or causes it to be uniform throughout the mass.

While the chemical reactions taking place during the hardening of concrete are not fully understood, it is thought that the lime takes no part in them but acts solely as a void filler, making the concrete more dense and therefore stronger and less permeable. An examination of a piece of concrete mortar will show a certain percentage of fine voids. These are more pronounced where the mortar has been in contact with a piece of the coarse aggregate. By the aid of a microscope of even moderate power smaller voids may be seen throughout the mortar generally. If the material is subjected to the action of water it is to be expected that these voids will become filled. The resulting action on the concrete when the frost reaches these small, water-filled cavities will, to say the least, be deleterious. In warm weather when the danger from frost is not present the water may contain salts or other materials in solution which will have a disintegrating action. Thus, in all seasons the mass is exposed to danger so long as these capillary chambers exist.

It is, therefore, essential that the voids be filled, or reduced to a minimum. It is generally thought sufficient to have the material entering into the concrete so proportioned that the voids in the coarse aggregate are completely filled by the mortar, those in the fine aggregate being filled with cement, with a slight excess of the latter. Concrete so proportioned, properly wetted, mixed and tamped, is considered dense. Simple tests will show that no amount of mixing or tamping, or even the addition of an excess of cement will entirely eliminate the small voids. So long as they exist the mass will be subject to expansion and contraction to a greater degree than if they were filled with material. This is the purpose that is believed to be served by the hydrated lime. The results of tests in actual conditions, as well as those made in the laboratory, show that there is a decrease in the contraction of the material, that it is more impervious to water, and that with certain percentages of lime added there is a resulting increase in strength.

With these facts determined it was natural that favorable results should be expected from the use of hydrated lime in concrete pavements. When laid in this form, concrete is subjected to what is perhaps its most severe test. In addition to being under static and live loads, it is exposed to extreme climatic conditions. The temperature in the southern portion of Ontario commonly ranges from 95 degrees in summer to 20 degrees below zero during short periods in the winter months. In addition, the snow lies on the ground for at least three months of the year, attaining a depth of from 12 to 24 inches on the level. The average frost line is about three feet below the surface of the ground. When, together with these conditions, it is remembered that concrete in a pavement has a greater area of surface exposed, per cubic yard of material, than in any other class of work, the necessity of obtaining a thoroughly dense material with the minimum coefficient of expansion, is realized.

In the summer of 1913 a section of concrete road containing hydrated lime was laid by the Office of Public Roads and Highways near Sarnia, Ont. The road is 5,946 feet long, 16 feet wide and 7 inches thick, one-course construction being used. Gravel shoulders 4 feet wide, bound with limestone screenings, were laid on the sides. Expansion joints filled with paving pitch were placed at 30-foot intervals. The gravel used, was supplied from the St. Clair River at Point Edward.

The hydrated lime, which replaced 10 per cent. of the cement by volume, was mixed with the cement in a small

gasoline-driven mixer and rebagged. The cost of this was $0.084 per square yard of pavement laid. One carload of cement was thus handled per working day. At the present time this pavement is in first-class condition, showing but a few cracks, in spite of the fact that tons of heavy machinery were hauled over it in connection with building operations on adjoining property.

The writer conducted a preliminary set of laboratory investigations with a view to determining, if possible, the factors affecting the use of hydrated lime in Portland cement mortars.

Tests were made to determine the following properties: Tensile strength, compressive strength, rigidity, toughness and resistance to wear.

A fine, clean, pit sand was chosen, the fineness being considered advisable, tending towards consistent results. The Granulometric analysis gave the following:

Screen	No. 10	No. 20	No. 30	No. 40	No. 50	No. 100	No. 200
Per cent. passing	98.9	92.3	46.9	21.7	21.7	2.0	.4

Silt present, 0.2 per cent.

The Portland cement was of average grade and had the following properties: Specific gravity, 3.15. Per cent. retained, No. 100 screen, 5.3; No. 200 screen, 19.2. Initial set, 1 hour 30 minutes. Final set, between 4 and 5 hours. Acceleration test showed no checking or cracking. Strength of neat cement at 24 hours, 240 lbs. per square inch. Strength of neat cement at 7 days, 525 lbs. per square inch. Strength of 1 : 3 mortar of standard Ottawa sand at 7 days, 200 lbs. per square inch.

The hydrated lime used was obtained from the Provincial Prison Farm at Guelph, Ont., and has the following analysis: Magnesia (MgO) 33.1 per cent.; calcium oxide (CaO) 43.5 per cent.; silica, alumina, etc., 23.4 per cent.; class of lime, Dolomitic.

The mortars used, with the proportions of lime added, were:

Series.	Mortar.	Per cent. lime.	Series.	Mortar.	Per cent. lime.
A-1	1-2	0	B-1	1-4	0
A-2	1-2	4	B-2	1-4	8
A-3	1-2	7	B-3	1-4	15
A-4	1-2	10	B-4	1-4	25

The weight of lime is based on the weight of cement, both dry, and is added to it, not replacing it.

The dry cement and lime were screened together twice and turned over three times. The water was then added and the mass turned six times with the shovel. The consistency in each case was standard throughout the tests, the mixture being on the wet side, although not sloppy.

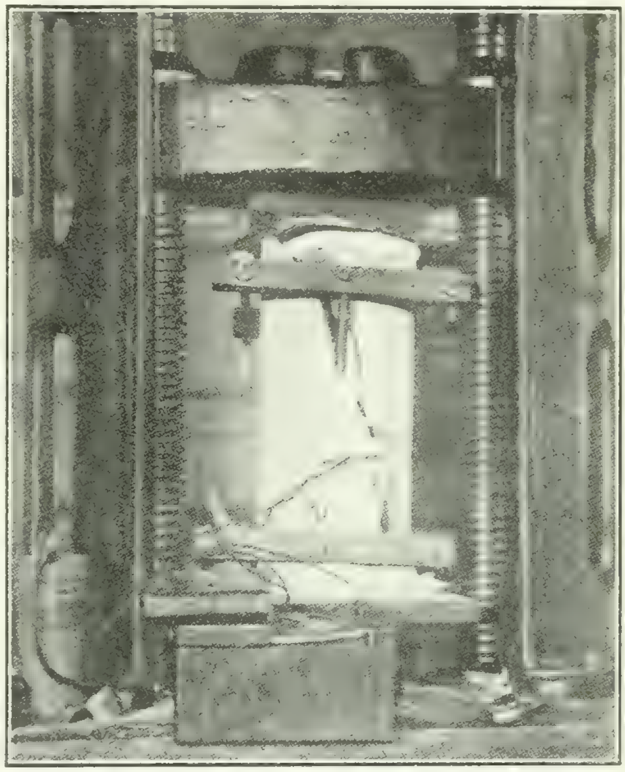
In placing in the moulds care was taken that each specimen received the same amount of tamping and packing. The chances for error due to variations in this operation were reduced to a minimum.

At the end of twenty-four hours the moulds were removed and the material dried in air for thirty-six hours, when it was immersed in water, being completely covered. Any loss due to evaporation of the water was made up from time to time.

The tests for tensile strength were made on standard cement briquettes, with a Reihlé shot machine. Twelve briquettes were tested and the average of those giving the most consistent results recorded.

The tests for compressive strength and rigidity, or modulus of elasticity in compression, were made at the same time. The cylinders, measuring 8 x 18 inches, first being capped with plaster of paris, were placed on an adjustable block on the testing machine. A metal plate was set on the top and the head lowered slowly. The adjustable blocks were set so that the top plate was parallel with the head in order that the pressure would be evenly distributed over the surfaces.

The reduction in length was determined by means of a compressometer with 12-inch centres. The micrometer screws read to .00001 inch and were fitted with electric contacts, providing a very accurate adjustment. The reading for no load being taken, the load was applied and the compressometer readings taken. Sufficient readings were taken to give from 12 to 15 points on the stress-strain curve. The type of clamps used with the compressometer were such that it was possible to leave the instrument on



Compression Test Specimens in Testing Machine, Showing Methods of Attaching Compressometer.

the cylinder throughout the test for compressive strength; that is, until the cylinder failed.

The testing machines used were the Riehlé 100-ton, vertical machine, and the Riehlé 50-ton, vertical machine. The cylinders from series "A" were tested on the former as their strength exceeded the capacity of the smaller machine. Series "B" were all tested on the 50-ton machine. Both machines were adjusted before the commencement of each test.

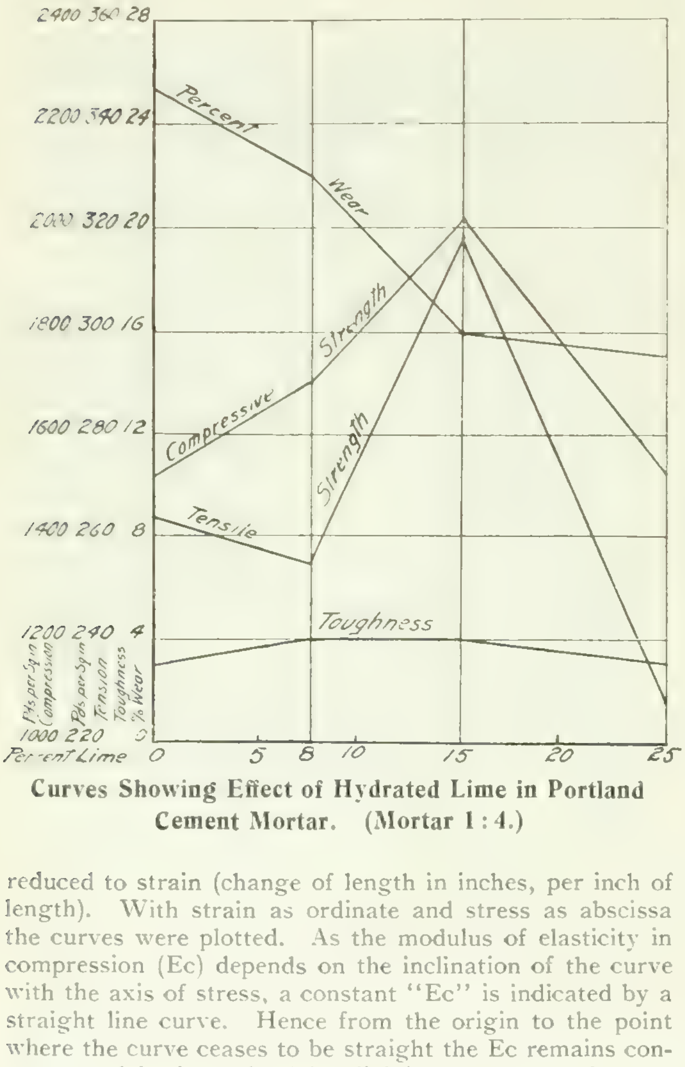
The methods of attaching the compressometer and applying the load are shown in the accompanying photograph. All the cylinders of series "A" failed suddenly with a loud report, while those of series "B" failed slowly with a "crunch," usually after the load had been constant for some seconds. In several cases it was impossible to get a definite reading at the point of failure on series "B" as the fatiguing of the material caused a continuous change of length until failure took place. In series "A" the point of failure came in every case with an increase in load, indicating that the 1 : 2 mortar withstood fatigue longer than the 1 : 4 mortar.

The tendency to produce cones was shown, in every case with series "A" and in several cases with series "B," these latter not being so well formed. The forms that the cones took together, with one cone still in position, is shown.

The compressive strength was calculated by dividing a load in pounds on the cylinder at failure by the area in square inches. This gives the compressive strength (ultimate) in pounds per square inch.

The points on stress-strain curves were calculated and plotted in the following manner:

For a given load in pounds per square inch, the average difference in the compressometer readings was



Curves Showing Effect of Hydrated Lime in Portland Cement Mortar. (Mortar 1 : 4.)

reduced to strain (change of length in inches, per inch of length). With strain as ordinate and stress as abscissa the curves were plotted. As the modulus of elasticity in compression (Ec) depends on the inclination of the curve with the axis of stress, a constant "Ec" is indicated by a straight line curve. Hence from the origin to the point where the curve ceases to be straight the Ec remains constant, and is determined by dividing the stress by the strain. Thus

$Ec = C/S$, where Ec is the modulus of elasticity for concrete.

C is the stress, and

S is the strain.

The quotient gives what might be called the average modulus of elasticity, covering a range of stresses from zero to the point calculated. As stated before, where the curve has a constant inclination to the axis of stress a calculation for any point on the curve will give the same value.

The stress-strain curves were calculated for the test from which it was possible to get the greater number of readings near the upper portion of the curve. Two cylinders were tested for each mortar in order that a check might be had. In practically every case the test readings checked closely; consequently in order that the curves might be easily read, the one giving the most points was recorded.

The test for toughness was made on 1-inch cubes. These were tested on the impact machine for testing the toughness of rocks. The test consisted of repeated blows of the hammer, starting with a fall of 1 cm. and increasing by 1 cm. for each succeeding blow. The number of blows required to cause failure represents the toughness of the material. The average of two tests was recorded.

The test for resistance to abrasion was made in the Deval abrasion machine. The pieces from the briquettes broken in the test for tensile strength were placed in the cylinder, after weighing, and given 6,000 revolutions at a rate of 33 per minute. They were then removed, carefully cleaned and weighed, the loss of weight by abrasion being expressed as a percentage of the original weight.

Series "A," Mortar 1 : 2.

Lab. No.	Per cent. Lime.	Tensile Strength.	Compressive Strength.	Per cent. Wear.	Toughness.
A-1	0	267.2	2,540	7.88	5
A-2	4	305.5	3,715	7.625	5
A-3	7	335.5	3,970	5.600	6
A-4	10	328.0	3,425	5.000	5

Series "B," Mortar 1 : 4.

Lab. No.	Per cent. Lime.	Tensile Strength.	Compressive Strength.	Per cent. Wear.	Toughness.
B-1	0	264	1,520	25.40	3
B-2	8	255	1,700	22.00	3
B-3	15	318	2,015	16.00	4
B-4	25	227	1,520	15.00	3

Series "A" Values of "Ec" up to 1,200 lbs. per sq. in.	Series "B" Average values of "Ec" up to 800 lbs. per sq. in.
A-1 .... 3,337,500 lbs.	B-1 .... 2,650,000 lbs.
A-2 .... 3,080,000 lbs.	B-2 .... 2,500,000 lbs.
A-3 .... 3,337,500 lbs.	B-3 .... 2,350,000 lbs.
A-4 .... 2,925,000 lbs.	B-4 .... 2,425,000 lbs.

Observations.—With the addition of hydrated lime to the 1 : 2 mortars an increase of tensile strength was observed, reaching the maximum in a mortar containing 7 per cent. lime. Beyond this point the tensile strength decreased. In the 1 : 4 mortars the maximum tensile strength was developed by that containing 15 per cent. of lime, a falling off taking place when this was exceeded.

The same variation was noted in the compressive strength, a 7 per cent. lime content giving the highest values with a 1 : 2 mortar and a 15 per cent. lime content with the 1 : 4 mortars.

The observations and calculations for the modulus of elasticity for the 1 : 2 mortars did not give as definite variations as in the other tests. There was little variation in the mortars containing from 0 to 7 per cent. lime, a very slight decrease being recorded for the 4 per cent. lime content, the same value being obtained with 7 per cent. as with 0 per cent. lime. With the 1 : 4 mixtures a smaller variation was found but a slight decrease in the values, as the percentage of lime was increased. The decrease between 0 and 15 per cent. lime contents was slight.

An increase in toughness was found in the 1 : 2 mortars, reaching a maximum with that containing 7 per cent. lime and an increase, to maximum at 15 per cent., with the 1 : 4 mortars.

(Continued on page 610.)

WATERWORKS RESERVOIRS.*

By Dabney H. Maury, Mem.Am.Soc.C.E.

[The purpose of Mr. Maury's paper is to discuss governing considerations in reservoir design, show a few typical designs, describe difficulties encountered in actual construction, and to make suggestions which may assist engineers to overcome some of these difficulties.—EDITOR.]

IN any waterworks system there are usually a number of steps which lie between the taking of water from its original sources and the actual delivery of it to the consumer. These steps include some or all of the following: (*a*) The collection and storage of the water of a stream in an impounding reservoir. (*b*) The pumping of water from a stream or lake or from wells to a suction reservoir, or to a settling basin, or to filters, or directly into the distribution system. (*c*) The purification of the water either by sedimentation, or by filtration, or by both. (*d*) The pumping of the water from the surface reservoir, or from the sedimentation basin, or from the clear water reservoir of the filters, into the distribution system. (*e*) The actual delivery of the water from the distribution system to the various consumers.

Field of Usefulness.—The usefulness of any reservoir depends upon, and is limited by, the position which it occupies in the order or procession of the steps just enumerated.

For example, if it be an impounding reservoir it can do no more than store the waters of the stream above it, and is of no value in conserving or helping out the capacity of the low-lift pumps which take their supply from it; or of any suction reservoir, or filter plant, or clear water reservoir, which may follow it; or of the high-lift pumps; or of the distribution system. If it be a suction reservoir or clear water well, then it will help out the capacity of everything back of it, which may be a stream, an impounding reservoir, wells, or low-lift pumps taking water from any of these sources and delivering it into the reservoir under consideration, or a water purification plant which may discharge into it. Such a reservoir does not, of course, conserve the capacity of the high-lift pumps which draw from it, or of the distribution system into which its waters are discharged.

A distributing reservoir, located on the discharge side of the pump and connected to the distribution mains, has more of these steps back of it than any of the other reservoirs just enumerated, and its usefulness may include the conservation of the capacity of stream, or of impounding reservoir, or of wells, or of sedimentation basins, or of filter plant, or of low-lift pumps, or of high-lift pumps, or of all of these together.

A distributing reservoir properly located will, in addition to all of the foregoing, help out the capacity of the distribution mains themselves, and this last and very important function has in the past been frequently overlooked.

It follows from what has just been said that the nearer a reservoir is to the beginning of the order or procession of the successive steps in water supply, the less will be its value, other things being equal; and that the further along in this procession of steps, the greater will be the value of the reservoir.

Value of Proper Location of Distributing Reservoirs.—In order to derive the greatest possible benefit from a distributing reservoir, it should be properly located; and the intrinsic value of the proper location of such reservoirs has not always been appreciated in the design of waterworks systems. Where small waterworks plants have elevated storage, one frequently sees the tank located on the pumping station lot. A tank so located is in most cases a monument to the bad judgment of the man who designed the plant.

To illustrate the point, two cases, out of many that could be mentioned, will be cited:

In the first case the main pumping station was two miles north of the centre of the congested value district in a small city. The elevated storage reservoir, originally built close to the pumping station, had been destroyed, and it was necessary to provide a new one.

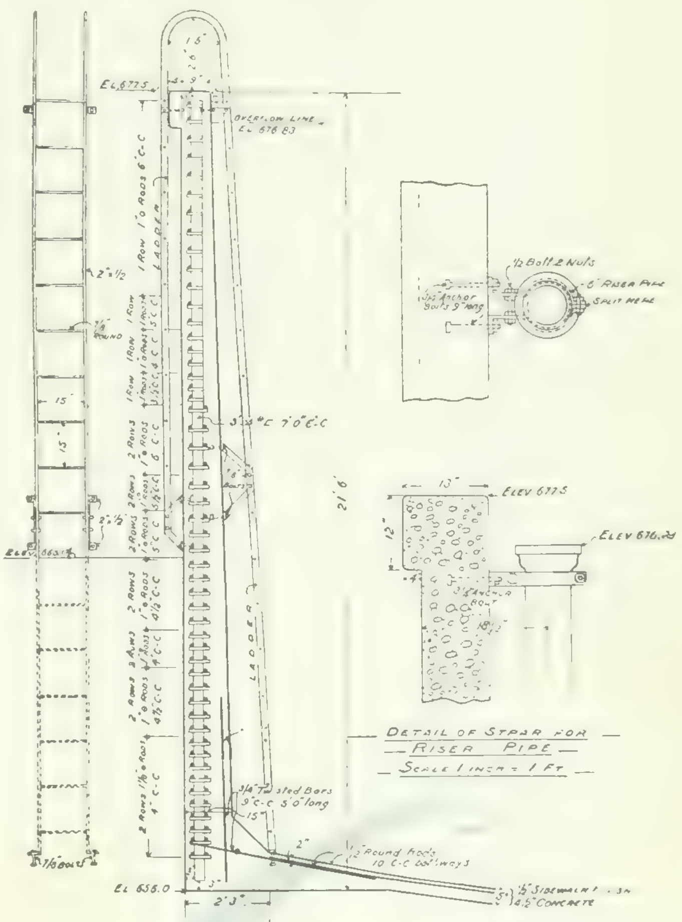


Fig. 1.—Wall of 2,000,000-Gallon Reservoir.

For the purpose of computing the friction losses it was assumed that a fire broke out during sprinkling hours on a hot day in summer and that the plant would be required to furnish water at the rate of 4,000 gallons per minute, distributed throughout the city for domestic consumption, in addition to a supply of 2,000 gallons per minute for fire service, which latter amount would be drawn at or near the centre of the congested value district. It was found that if the tower and tank were located close to the pumps at the northern end of the city the pressure remaining in the mains in the congested value district would be only 25 pounds, whereas with the same elevated tank located near the southern end of the town the pressure remaining in the mains would be more than 53 pounds. To save this difference of 28 pounds by laying additional mains from the pumping station to the congested value district would have involved an expenditure

*Abstract of paper read before the American Water Works Association, June 7th, 1910.

of at least $30,000; so that it may be fairly stated that the advantage obtained in this case by locating the elevated storage near the centre of the congested value district instead of at the pumping station was worth not less than $30,000.

In the second case, which involved a city of larger size than the one just mentioned, a site for an elevated reservoir of a capacity of 7,500,000 gallons has been selected on an eminence opposite the main pumping station. The congested value district in this city was comparatively small, and its centre was more than three miles south of the pumping station. A topographic map

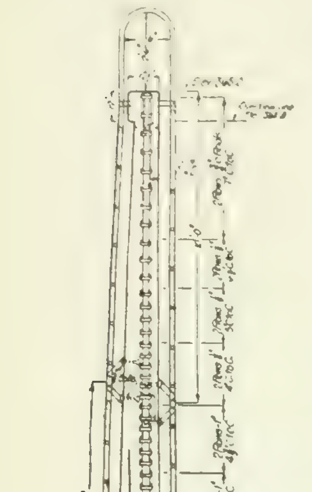


Fig. 2.—Wall Section, Old Reservoir.

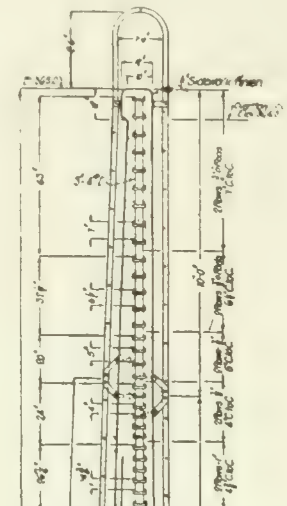


Fig. 3.—Wall Section, New Reservoir.

had been made of the proposed reservoir site, and test pits had been sunk through the top soil to bedrock, when the writer was called in to pass upon the suitability of the topography and soil conditions for a reservoir of the capacity contemplated. It was at once apparent that the location of the reservoir with regard to the pumping station, to the distribution system of mains and to the territory to be supplied, was far from being a desirable one. An examination was made of high ground opposite the congested value district, with the result that a much more suitable site was discovered, which was later purchased by the city.

Among the first points to be determined are the location, capacity and elevation desired. These having been at least approximately determined, the work of designing may be begun.

Some Typical Designs.—Fig. 1 shows in cross-section the wall and part of the bottom of a 2,000,000-gallon reservoir, 120 feet inside diameter, 19 feet 10 inches deep at the wall, and 24 feet 10 inches deep at the centre. This reservoir was built partly in excavation and partly in embankment on clay soil. Its bottom, which was 5 inches thick, was reinforced throughout with steel sufficient only to resist temperature stresses. The reinforcement in the wall was continuous around the circumference, and was designed to resist the internal pressures just as the hoops on a barrel resist the internal pressures in the barrel.

Fig. 2 shows in cross-section the wall of another reservoir in which the steel reinforcement was stressed as are the hoops in a barrel. This wall was built to enlarge the capacity of an existing reservoir by increasing its depth from 14 to 32 feet. The inside diameter of the reservoir, as enlarged, was 142 feet, and its capacity about 4,000,000 gallons. Right alongside of this old reservoir was constructed a new one which was so designed that the part of it which showed above the finished grade should be an exact duplicate of the enlarged old reservoir, and Fig. 3 is a section through the wall of the new reservoir. Here again the reinforcing steel is subjected to hoop stresses.

Fig. 4 shows an entirely different type of reservoir, with beam and slab roof, slab walls and slab bottom for the bay next to the walls on each side, the remainder of the bottom being of the inverted groined arch type. This is not a distributing reservoir, but is intended to serve for the present as a storage reservoir for water pumped into it from distant wells. The reservoir is, however, so designed that later on its columns may serve as supports for an iron removal plant to be built on top of it, and it will then serve as a clear water reservoir. At times of very high water, the ground water, if it were unaffected by the pumping operations at the adjacent pumping station, would rise as high as the top of the reservoir, and if the reservoir were empty as such a time, the total upthrust would be greater than the weight of the reservoir and of its covering.

While it is not likely that there will ever be a time when the pumping operations at the station will cease for any long period, coincident with the pumping out of the reservoir itself, provision was nevertheless made to guard against any such contingency by sinking in each corner of the reservoir a 10-inch well equipped with a strainer of liberal area, having openings so large that they cannot become clogged by rust, and with a check valve opening into the reservoir. Should the ground water outside of the reservoir at any time rise higher than the water inside, these four wells will admit water to the reservoir with sufficient rapidity to prevent any danger from the unbalanced pressure of the ground water.

These wells were sunk before the construction of the reservoir was begun, and by pumping from them, the ground water, which would otherwise have stood several feet above the bottom of the reservoir, was held down below the bottom during the entire construction period, so that the whole structure was built in the dry.

Some Construction Difficulties and Some Suggestions.

The first thing naturally demanded of a waterworks reservoir is that it shall hold water, and as a rule the most difficult part of the construction of a reservoir is making it watertight.

A small amount of leakage really does no great damage; but so long as any leakage can be detected, it is an eyesore, and it remains as a reproach to all of those in any way connected with the design or construction of the reservoir, whether contractor, engineer or owner. For these reasons, leaks so small that they could do no harm whatever are not, as a rule, permitted in the finished structure, even though the cost of stopping them is out of all proportion to the value of the water lost.

It is not an easy matter to build a reservoir which shall be absolutely watertight from the time the forms are removed. Fortunately, however, very small leaks will usually become less or "take up" in a short time, especially when the stored water contains iron or sediment, and in most cases it is not very difficult to stop large leaks or at least to reduce them to so small an amount that they will ultimately stop of themselves.

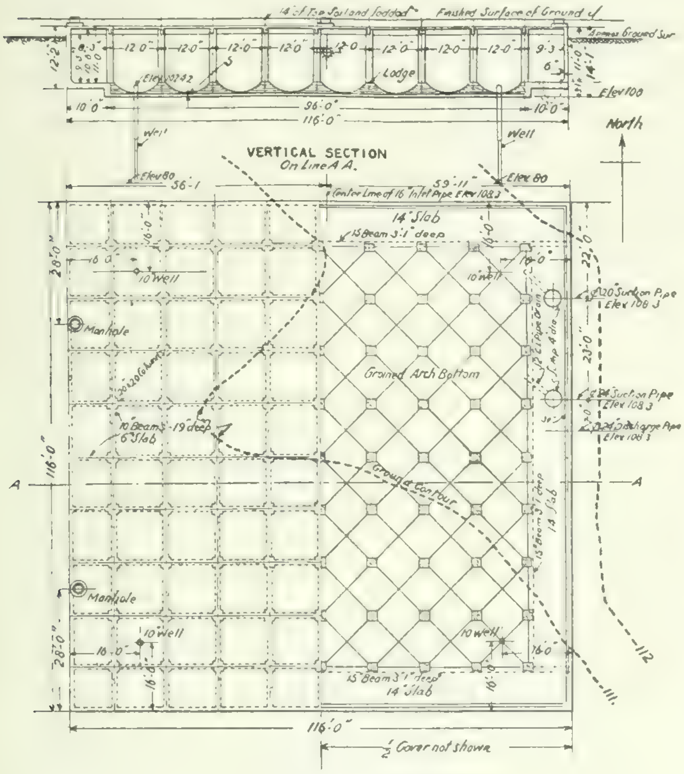


Fig. 4.—Plan and Section of 1,200,000-Gallon Covered Reservoir.

As a result of his experience with these and with a number of other concrete reservoirs, the writer would draw the following conclusions:

1. It is entirely possible with proper materials, mixture and workmanship to prevent moisture from passing through a concrete wall a foot thick, even under fairly heavy pressures.

2. It is not to be expected, however, that the perfection of workmanship required to produce these results will always be obtained at every single point over an area of thousands of square feet of wall.

3. Such leaks as may show in spite of conscientious efforts to do good work can almost invariably be stopped entirely or be reduced to such a point that they will stop themselves in the course of time, especially if the water carries iron or sediment.

4. Leaks are most likely to occur at construction joints. The use of steel dams will reduce the danger of such leaks, but these dams cannot always be relied upon to prevent the leakage, and their presence should not be allowed to diminish in any way the precautions which should always be taken to prevent leakage at the joints.

5. The surface of concrete which has begun to set should be scratched and roughened, and all dust, rubbish and laitance should be carefully removed with a vacuum cleaner before the next batch of concrete is poured. This will not always prevent leakage, but it will go far towards doing so.

6. In reservoir construction the use of chutes for conveying concrete to its place in the wall should not be permitted unless the concrete is thoroughly remixed just before it reaches its final place in the wall.

7. While good results can be obtained by very careful spading of the concrete adjacent to the forms, so as to keep the stone away from the inner surface of the wall, it is believed that far better results would be secured by the plan devised by the contractor for the 10,000,000-gallon reservoir already described; namely, the use of a portable sheet of thin metal with means for holding it about ¾ inch away from the inner form, the concrete to be poured back of this sheet of metal, and cement mortar in front of it and between it and the form.

RAILWAY EARNINGS.

The following are the weekly railway earnings for May:—

Canadian Pacific Railway.

	1916.	1915	Increase
May 7	$2,763,000	$1,504,000	+ $1,160,000
May 14	2,592,000	1,604,000	+ 988,000
May 21	2,610,000	1,575,000	+ 1,035,000
May 31	4,222,000	2,223,000	+ 1,999,000

Grand Trunk Railway.

May 7	$1,030,768	$ 863,105	+ $ 167,573
May 14	1,076,436	922,106	+ 154,330
May 21	1,088,670	938,386	+ 150,293
May 31	1,482,053	1,291,615	+ 190,438

Canadian Northern Railway.

May 7	$ 677,400	$ 419,600	+ $ 257,800
May 14	748,300	364,800	+ 383,500
May 21	693,100	387,500	+ 305,600
May 31	970,100	541,500	+ 429,600

The Canadian Pacific Railway net earnings for April totalled $3,733,736 as compared with $2,687,753 during the corresponding period in 1915. Gross earnings for the month were $10,881,306, and working expenses $7,147,590.

The figures for the ten months of the current fiscal year show gross earnings totalling $105,117,108, working expenses $63,953,104, and net profits of $41,164,004. For ten months ended April 30th, 1915, net profits were $28,458,594.

The gross earnings of the Grand Trunk Railway System for April were $3,584,828, while expenses amounted to $2,344,104, making the net revenue for the month $1,240,-724, as compared with $1,167,492 for the same period of 1915, an increase of $73,232, or 6.2 per cent.

The earnings and operating expenses of the Canadian Northern system for April were as follow:—

	1916	1915	
Gross earnings	$2,824,300	$1,948,900	+ $875,400
Expenses	2,274,400	1,404,500	+ 869,900
Net earnings	549,900	544,400	+ 5,500
Mileage in operation.	8,270	7,248	+ 1,022

The New York State Public Service Commission, First District, reports that on a typical day the number of persons passing over the four bridges across the East River, between Manhattan and Brooklyn, in a period of 24 hours, was [illegible]

EQUITABLE SPECIFICATIONS AND CONTRACTS.*

By Hillis F. Hackedorn.

THE American Society of Engineering Contractors, ever since its organization in 1909, has had a number of ideals to which it has clung tenaciously. One of these is the idea of equitable specifications and contracts; specifications that are written fully and completely describing the work down to the minutest detail, eliminating all guesswork and conveying to the contractor completely the ideas of the engineer; describing fully what work he expects to do, how he expects to do it, sequence of the performance and the results he expects to obtain, leaving nothing for future argument, nothing for guesswork.

One of the greatest impositions that is ever placed on the contractor is by the engineer whose specifications fairly teem with the expression "to the satisfaction of the engineer." This very-much-abused, never-understood, and impossible-to-forecast expression is about as serious a handicap as can be hung onto a contractor who is making up an estimate of cost on any type of construction. It leaves such a wide field for guesswork, it opens up such a broad avenue of opportunity for the engineer or inspector to "get even" with the contractor for some fancied or real grievance. It is something against which a contractor has no opportunity whatever to protect himself.

This phrase impresses the contractor as an evidence of either lack of knowledge on the part of the engineer or laziness in preparation of the specifications, and in many instances the contractor views these clauses in the light of a club to be held over his head during the construction of the work. They impress him with the belief that the engineer *thinks* he wants certain things done but if the contractor learns during construction that the engineer wants something else done, the contractor must pay for the change. The engineer should be sufficiently advised and have sufficient knowledge of all conditions surrounding the work to enable him to make up a correct detailed guaranteed design and estimate. He should have the nerve to stand pat on his estimate and likewise should not expect the contractor to make good the cost of any mistake he may make in the preparation of plans and specifications; neither should the contractor be put to the expense of thoroughly checking the engineer's estimates, and all engineering and contractors' organizations should join in an effort to educate specification writers to a proper conception of what is fair and equitable to owners, engineers and contractors alike.

In Great Britain carefully prepared schedules as to quantities are submitted to the contractor. These quantities are guaranteed, and in case of error, the contractor has a ground of action against the quantity surveyor if his bill of quantities is wrong. This method enables the contractor to estimate much more closely as to the cost of the work than under customs in this country, where all estimates of quantities are *frankly* labeled as guesses, and the engineer dodges all responsibility by stating that the contractor must assume all the hazard as to errors in such estimates. Of course, the contractor, under these conditions, must charge for an element of chance which should not enter into the proposition. The engineer should make his estimates carefully and thoroughly and be ready to stand behind them in case of error. I know of but one bridge engineer who guarantees his quantity estimates and as a result bidders can make much closer estimates, knowing as they do, that he will stand responsible for any errors in his quantity statements.

An unfair engineering practice frequently resorted to in the writing of specifications is to require the contractor to prepare the detailed working drawings for the job, including, for reinforced concrete, bending diagrams and special details as to connections of reinforcement, thereby making it necessary for the contractor to maintain a much more extensive engineering and drafting department than would be otherwise required if the engineer did his full duty, preparing all detail plans and working drawings so that there would be no question in the contractor's mind, when he bid on the work, exactly how the work was to be executed to the most minute detail. In addition to this, some specifications require that the contractor "having checked the plans shall be responsible for the correctness of all drawings, as to dimensions, elevations and mutual correlation of various parts," thereby making the contractor absolutely responsible for the correctness of the engineer's design and drawings, and in case of an error, the expense of correlation is unfairly placed on the contractor. The contractor is given no extra allowance for preparing these drawings, but must do it at his own expense and deduct it from his estimated profits, when it should be taken from the engineer's fee.

Our position in the matter of detailed specifications is that we know of no legitimate reason why the contractor should not have full detailed information as to what will be required in the execution of a given contract *before* the contract is signed, rather than make haphazard guesses on small scale drawings and indefinite specifications frequently lacking in vital information. If detailed drawings have not been completed before the date upon which bids are requested, the date should be postponed to give the engineer an opportunity to prepare complete working drawings. It takes no longer to study the details of a structure before the contract is executed than after, and a careful preparation of detailed drawings and the writing of complete specifications, would frequently result in saving of cost to the owner because of the necessity of the contractor to add a certain percentage to cover the uncertainties of plans and specifications.

Another question in which many engineers err in judgment is in specifying a short time for completion and requiring the starting of work immediately upon the awarding of contract. A short limit reduces competition because it admits only the contractor who is fully equipped and ready to begin immediate work, and where a short time limit is provided, the engineer should include a certain compensation to cover the cost of night work necessary on the part of the contractor in order to complete the work within the time set. It has been our experience that where the engineer co-operates with the contractor, the quality of work is very much improved, resulting in a great benefit to the owner.

One manifestly unfair condition in many specifications is that of giving the engineers the right to make minor changes in the plans, without extra compensation to the contractor, unless "in the opinion of the engineer" he is entitled to such extra compensation, the amount of any such extra compensation to be determined solely by the engineer.' This condition leaves a very large opening and opportunity for the engineer to abuse his authority over a contractor whom he does not like, or seriously cripple him, when the wrong man, in the opinion of the engineer, has landed the job.

*Abstract from paper read before a joint meeting of the American Society of Engineering Contractors and St. Louis Section of the American Society of Mechanical Engineers.

In my mind, one of the greatest injustices which enter into nearly all specifications, is the clause requiring the contractor to "indemnify, keep and save harmless the owner and engineer from all liabilities, judgments or costs and expenses which may in any wise come against the owner or engineer on account of any infringement of any patent on the use of any design, material, machinery, device or apparatus used in the performance of the contract." In other words, the engineer goes along, prepares his design, specifies his materials and method of construction and puts the responsibility on the contractor for ascertaining whether or not there are any patents on the type of design, or material used, or on the method of construction. It seems to me that this is part of the duty of the engineer, and that in making his design he should ascertain beyond the possibility of a doubt whether or not his design infringes any of the many patents which have been granted by the Patent Office at Washington, and in case he cannot make a design without infringing a patent, he should either notify all bidders of the existence of such patent, and the fact that his design infringes, or he should obtain from the owner of the patent the right to use it for a specific price on the work. It is entirely unfair to shoulder this responsibility and liability on the contractor, in addition to the many other troubles which he has to guard against in executing the contract.

Another inequity is that of giving the engineer the right to direct the sequence of the work and issue orders as to the manner and time in which the various parts of the work shall be done, and the force required to complete it within the time specified. I believe I can state, without fear of contradiction, that no two contractors would handle the same job in the same manner and sequence. It is customary in making up estimates, to carefully plan the manner and sequence of the construction, and if the contractor is not permitted to follow his own methods, it frequently results in turning a contract, that would otherwise be profitable, into one that results in a loss to the contractor.

The business relations between the contractor and the engineer are little understood by the public at large. We, as contractors, realize that one of the most difficult problems confronting an engineer is the preparation of his specifications, in making them rigid enough to control the bad contractor and at the same time work no hardship on the contractor who is honest and sincere in his work.

The wise engineer knows that many contract conditions can be ignored without any harm being done, and that many facilities can be given the contractor to help expedite the work. We believe that the contractors as a body will not take unfair advantage of these concessions, but in their turn, will go out of their way, even at extra expense, to meet some special request of the engineer, playing the game of "give and take" in a reasonable way without expecting extra pay for every trifling piece of work, thus bringing about a great improvement in the relations between engineer and contractor and eliminating many of the disputes which at present are too frequent.

Signal horns, similar to automobile horns, are attached to lighting-poles along many of the busy thoroughfares of Washington, Baltimore, Binghamton, Bridgeport and a few other United States cities. When a fire alarm is rung the route to be travelled by the apparatus is quickly determined, and by electrical control at fire headquarters the alarm gongs are sounded all along the route. Traffic stops at once; the streets are cleared well in advance, and the fire apparatus [illegible]

CITY OF KAMLOOPS HYDRO-ELECTRIC PLANT.*

By H. K. Dutcher, M.Can.Soc.C.E.

It is the purpose of this paper to refer to some of the engineering and economic features in connection with the design and construction of the municipal power plant and pumping systems of the city of Kamloops, which have been recently completed and placed in service.

These systems include a steam turbine power plant and pumping system, a new reservoir and a hydro-electric power plant and sub-station.

The steam power plant and pumping system, together with the sub-station of the hydro-electric plant are included in the one building, and located near the eastern limits of the city, while the generating station of the hydro-electric plant is located on the Barriere River, which flows into the North Thompson, the distance of this plant from Kamloops being about forty miles almost due north.

To properly appreciate the relation of these systems one to the other and their importance in the general scheme upon which the plans of development were based, it is necessary to refer to some of the economic conditions affecting the growth of the city and the development of the surrounding districts.

The city of Kamloops is located on the main line of the Canadian Pacific Railway at the junction of the North and South Thompson Rivers, and for some years it has maintained the normal growth of a railway divisional point, and centre of a considerable ranching district. Very little attention has been paid to mixed farming in this district, due partly to the fact that most of the settlers were cattle ranchers, and also to the limited supply of water available from the streams for gravity irrigation systems.

When the richness of the lands in the "Dry Belt" had been more thoroughly appreciated, greater efforts were then made towards intensive cultivation, and many of the lands were divided into small areas for fruit trees, but as the precipitation on the district varies from ten to fifteen inches per year, the dependence upon limited sources for gravity irrigation systems, imparted a certain feeling of timidity with respect to the planting of crops and intensive farming. Consequently Kamloops has been obliged to import butter, eggs and other farming products which should have been supplied locally.

This condition would tend to affect the cost of living and the discouragement of much desired local industries, but when the plans of the Canadian Northern Railway included a route from Vancouver to Edmonton by way of Kamloops and the North Thompson River, the location of the city as a centre of some importance for future growth was more fully realized. Therefore, when the increasing demand for power, both for the municipal electric light and power service and for the pumping plant, was rapidly passing beyond the capacity of the old steam plant, it was decided to investigate the possibilities for an ample supply of cheaper power, with particular regard to hydro-electric development, in order that, if possible, electric power might be available to irrigate by pumping, the rich lands along the North and South Thompson Rivers.

During the course of examination of the several streams available for power within practical range of the city, there appeared to be some prospect that a company holding the power rights on the Adams River might de-

*From a paper read before the Vancouver Branch of the Canadian Society of Civil Engineers.

velop power from this source, in which case the lands along the South Thompson River would be looked after.

Attention was directed, therefore, mainly to an examination of the streams flowing into the North Thompson River, and of these the Barriere River appeared to answer the requirements for power development most satisfactorily, especially in view of the two large lakes available for storage, the heavy grade of the stream and the convenience of the transmission line passing down the valley of the North Thompson through comparatively open country with a prospect of a power market along the entire route.

It was estimated, however, that winter conditions of the Barriere River would affect the operation of the hydro-electric plant for probably an average of six weeks per year, and in view of the importance of the prospective power loads it was considered advisable to plan the auxiliary steam plant system with a capacity equal to the

The water for the city system was pumped in from a well located under the power house which was fed by two intake pipe lines carried out into the river about 100 feet, and the rapid growth of the city along the river above the location of the intake created a danger to the sanitary conditions of the water supply which required immediate attention.

After some study of these different factors affecting the immediate and future requirements, the city finally decided to proceed upon the following scheme of construction:—

(*a*) The development of a hydro-electric power plant on the Barriere River with a capacity of at least 5,000 h.p., of which the first installation would provide for 2,000 h.p.

(*b*) The construction of a new steam plant and pumping station in the city, the steam plant to provide for either oil or coal fuel, and to have the first installation up to 2,000 h.p. capacity. The pumping plant to include two

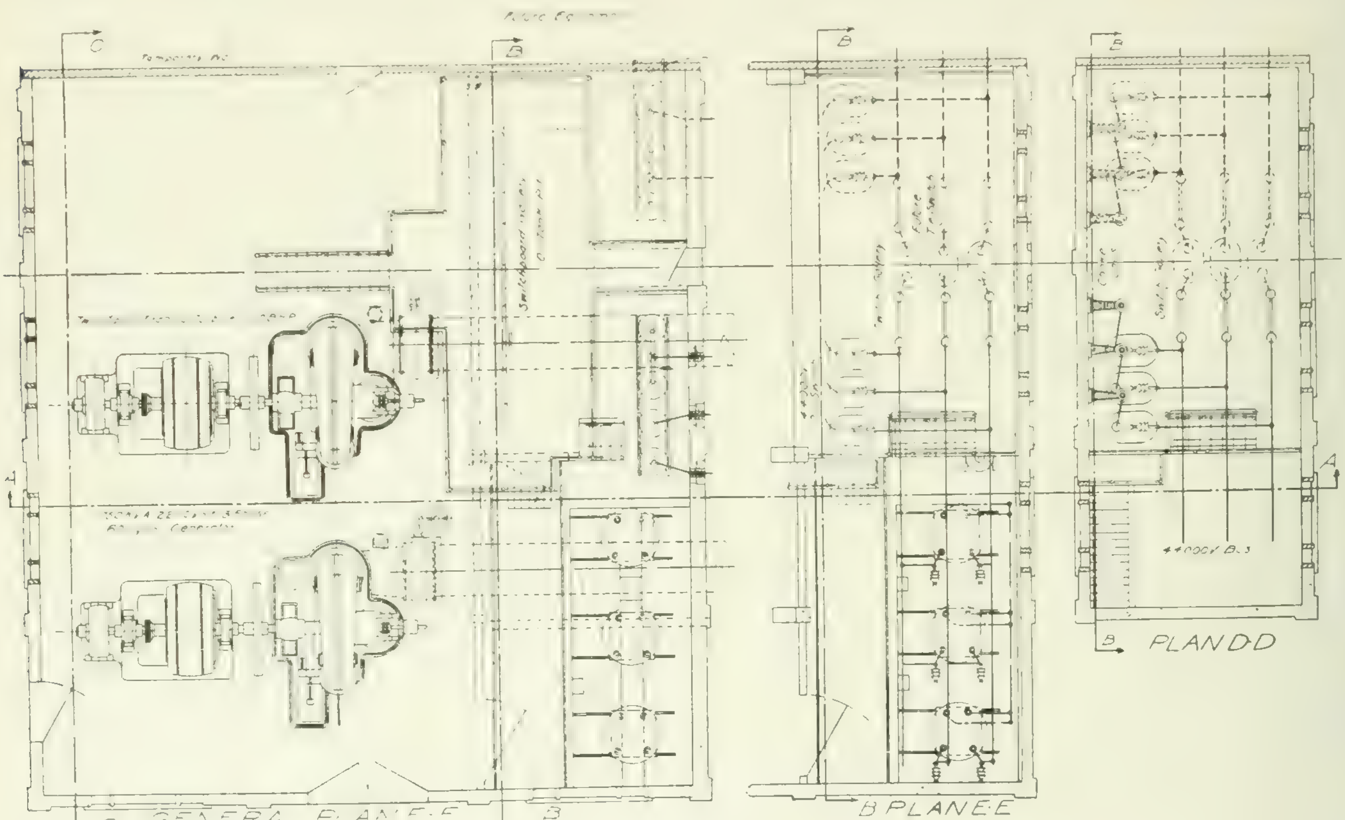


Fig. 1.—General Plan of City of Kamloops Municipal Hydro-Electric Plant.

hydro-electric plant, and to estimate the period of operation of the steam plant both as an auxiliary and reserve system for an average of six hours per day throughout the year, and the estimated cost of the combined system was, therefore, based on this condition.

The capacity of the old plant was about 500 h.p. and included three 150-h.p. return tubular boilers, two tandem compound steam engines, one belt-connected and the other direct connected to generators, and for the waterworks service there were two steam-driven plunger pumps, one with capacity of 1,000 gallons per minute and the other 700 gallons per minute. Both pumps, however, were in poor condition and were continually breaking down.

Moreover, it was impossible to keep a reserve supply of water in the reservoir for fire protection, as the capacity of this reservoir was only 150,000 gallons, and during the summer months the demand for water in the city exceeded [illegible] times this amount.

motor-driven centrifugal pumps to deliver 1,200 Imperial gallons per minute each, and one steam turbine pump of equal capacity.

(*c*) The construction of a covered concrete reservoir of 1,500,000-gallon capacity but designed for an extension to 3,000,000 gallons by the construction of a second section.

Barriere Hydro-Electric Power System, Barriere River.—The Barriere River rises in the mountains near Adams Lake, flows in a westerly direction for a course of about thirty-two miles and empties into the North Thompson River at a point about forty miles north of Kamloops.

On the main branch there is the North Barriere Lake, which is located about nineteen miles from the mouth of the river and receives the flow of numerous streams from the mountains. It has an elevation of over 2,100 feet above sea level, and an area at low water of 1,200 acres

with excellent conditions for storage of 30,000 acre-feet of water by the construction of a dam at the outlet.

At the distance of eight miles from the outlet of the North Lake the main branch is joined by the east branch, which empties from the East Barriere Lake, located about four miles from the forks and having almost the same elevation above sea level and an area of about 1,500 acres.

The total drainage area of the Barriere River is about 230 square miles, with an average precipitation of probably about 35 inches. The mean flow during a normal year would be about 550 cubic feet per second with extremes of about 3,600 cubic feet per second as a maximum in the early summer period, and 220 cubic feet per second in the low-water season of the winter months.

Of the total flow, about 80 per cent. comes from the North Barriere Lake, and with the provision of storage for 30,000 acre-feet in the East Lake, there should be no difficulty in maintaining a flow of from 300 to 350 cubic feet per second for power development.

Power Development.—As the elevation of the North Lake is about 2,100 feet above sea level and the elevation at the outlet of the river is about 1,150 feet, there is therefore an average grade of about 50 feet per mile. The plan of power development provided for the location of a generating plant at a point about five miles up from the mouth of the river.

For a distance of about 3½ miles above the site of the generating station the grade of the river averages 65 feet per mile, and a suitable site for an intake dam was located to give an effective head of 192 feet at the generating station by 17,800 feet of flume system.

While the plans provide for the ultimate development of 5,000 h.p. from the present intake, the first installation provides for 2,000 h.p. by two 1,000-h.p. units, which, with the installation of 2,000 h.p. in the auxiliary steam plant, would give the city a maximum of 4,000 h.p. to start with.

The location of the generating station of the Barriere hydro-electric plant was made, however, with the view to the abandonment of the present intake when the demand for power exceeds the economical maximum capacity of the combined Barriere and steam plant systems as developed, and the development of from 15,000 h.p. to 20,000 h.p. by constructing about ten miles of conduit system direct from the North Lake to the generating station to obtain an effective head of 600 feet.

Flume System.—The construction of the flume system, including the intake dam, forebay, and wasteways, was started in February, 1912, the work having been let in one contract, to William Greenlees, of Vancouver.

It was planned to have the entire hydro-electric plant completed, if possible, by the end of the year, and it was therefore important to complete the construction of the intake before the high-water flow of the river in May or June.

A mill was located near the site of the dam and the lumber required for both the dam and the flume was obtained from the timber limits close by the mill, some of the logs being brought down the river and others from the hillside above.

Intake.—The intake dam is a standard rock fill crib type set with a pile foundation to ensure greater stability. The site chosen enabled a suitable intake to be obtained by raising the level of the water ten feet from the normal level of the stream to the crest of the spillway, the grade of the river above this point being such that the flood level extended about 1,600 feet up stream.

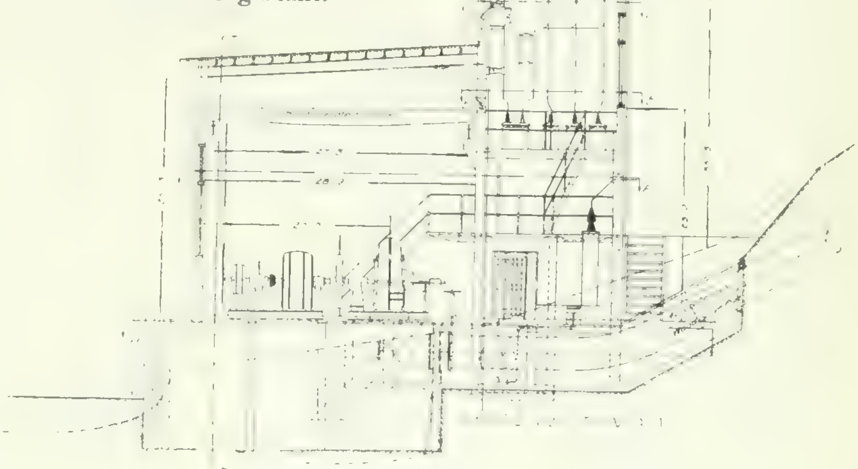
The accompanying plan shows the general details of construction, from which it may be noted that the length of the crest is 240 feet, the spillway 110 feet and of sufficient depth to take care of a maximum flow of 7,000 cubic feet per second.

The intake for the flume is located on the north side, and a logway and a fishway are placed on the other side of the spillway, the logway being 12 feet wide and the fishway built in accordance with the requirements of the Provincial Government.

The beds of the stream at the site chosen consisted of a top layer of boulders, underlaid with alternate layers of quicksand and blue clay, but a satisfactory degree of watertightness was secured by carrying the toe sheeting down to a depth of 12 feet, with the filling of mastic and puddled clay, an earth fill being made over this and carried to a height near the spillway by an easy slope.

The foot of the spillway was carried well down stream on piling, to take care of logs and roots which might get past the boom above the dam. The work was completed without difficulty by the middle of April, and passed satisfactorily the severe test of the high-water flow of the following months.

Fig. 2.—Cross-section Kamloops Municipal Hydro-Electric Generating Plant.



Flume.—The flume is designed for an ultimate capacity of 320 cubic feet per second and is 3.4 miles in length from the intake to the forebay. In design it is the standard type of timber flume, 8 ft. wide by 5½ ft. high, built up of 2 x 10-in. fir lumber, supported every four feet, and resting on trestle or cedar sills.

The quality of the lumber available was good, but a better quality of coast fir was used for battens and flooring at those sections where watertightness was especially desirable. Probably the only section which required special attention in this respect was a length of about 1,000 feet, two miles from the intake, where the flume was carried past a steep bank at a horseshoe bend of the river. There appeared some danger of a slide occurring at this section, either from undercutting of the banks of the river or from water running down from the melting snow or leakage of the flume.

It was desirable, however, to continue the flume, if possible, along this section, in view of the necessity of getting timber down from the mill for the construction of the system, and to avoid the heavier expense of carrying

syphon across the river, the cost per foot of the syphon being about four times the cost of the flume for an equal capacity.

The flume system, including wasteways and forebay for penstocks, were completed in the fall, and unfortunately the city was then obliged to shut down on all work on the hydro-electric plant on account of the failure to sell the balance of the hydro-electric bonds due to the financial stringency.

The system as completed was tested out, however, and found to be in satisfactory condition for service, but when the completion of the plant was carried out, two years later, it was found necessary to build the syphon at the section above referred to, on account of a slide occurring which carried away about six hundred feet of the flume. This syphon is built with capacity for half the ultimate capacity of the system. It is wood-stave pipe construction, 66 inches in diameter, 2,100 feet long and designed for varying head to a maximum of 120 feet.

The advisability of covering the flume as a protection against snow was considered, but as the design provided for a velocity varying from 6½ to 7½ feet per second, and careful inspection was required during the first winter's operation, it was decided to leave the system open until the need of a cover could be better determined from actual experience.

Forebay.—The forebay is of timber construction and located in a small depression, so that a hogsback lies between the forebay and the power house as a protection against accident to the water system. Its general dimensions are 18 ft. by 36 ft. long and 12 ft. deep, with ample provision for overflow to a wasteway down a small ravine to the river.

Penstocks.—There are two 42-inch penstocks from the forebay to the power house, each 490 feet in length. They were built by the Vancouver Wood Pipe and Tank Company and are of wood-stave pipe construction with staves 2½ inches thick and steel bands of ½ in. to ¾ in. diameter, spaced for pressure head from 30 ft. to 210 ft. Each penstock was connected up with its turbine by 28 feet of steel riveted pipe, anchored in concrete and connection between the wood-stave and steel pipes was made by an expansion joint.

Generating Station Building.—As already noted, the location of the generating station was governed not only by the plans for the present development, which can be brought up to at least 5,000 h.p., but the prospect of a future development of from 15,000 h.p. to 20,000 h.p. by a conduit system direct from the North Barriere Lake was also considered.

At the site chosen, the sub-surface conditions of alternate layers of gravel, quicksand and blue clay, required that the entire foundations of the building should rest on piles, and these were driven to an average depth of about 30 feet to secure a firm support.

The entire structure was built of reinforced concrete, the details for the tailrace and supporting walls, and beams for the units requiring considerable form work. The sand and gravel for the concrete was obtained close by the plant, and there were no unusual features of construction worthy of special mention.

The accompanying plan and elevation of the building show the general arrangement and some details of construction. The building as completed is intended to form half of the final structure, the construction of the other half will be carried out when other units are required.

The present dimensions are 45 ft. by 48 ft., making the structure, when extended, 45 ft. by 96 ft. It will be noted, on referring to the plans, that the arrangement for the installation of the equipment is fairly compact, although the high-tension equipment is well separated from the other section. The construction of the generating station was carried out by Wm. Greenlees, of Vancouver.

Turbines.—There are installed two horizontal turbine units of 1,100 h.p. each, manufactured by the Platt Iron Works, of Dayton, Ohio, and installed by the C. C. Moore Company. They are the single discharge, inward flow type, mounted in scroll casings divided horizontally, and were designed to operate for 190 feet head at 600 r.p.m.

The runners are of bronze, 28-in. diameter, with a pump-head speed of 66 per cent. of the spouting velocity. The installation of each unit included a cast steel flywheel 5 ft. 6 ins. diameter, a 42-in. butterfly valve hand-operated, and a 10,000 foot-pound direct connected oil pressure type Lombard governor.

The guaranteed efficiency of the turbines was 81 per cent. at full load and 84 per cent. at 80 per cent. full load; regulation 2 per cent. with 250 h.p. thrown off to 10 per cent. by 800 h.p. off, and 20 per cent. by 1,100 h.p. off, under two-second movement of governor.

Generators.—The generators were supplied by the Canadian Westinghouse Company. They are direct connected to the turbines and are designed for 750 kw. at 3-phase, 60-cycle, 2,200 volts. On the same bed plate and direct connected to each generator is a 40-kw., 125-volt, 600 r.p.m. exciter, each exciter capable of exciting both generators when necessary.

There were two banks at three 500 kv.a. transformers wound for 2,200 to 44,000 volts, oil-insulated and water-cooled. One bank for the generating station and the other for the sub-station at Kamloops.

Switchboard.—The switchboard includes at present seven panels of natural black slate. They are mounted on a gallery commanding a full view of the units and have the usual standard switchboard equipment for low and high-tension control. The panels are placed with a view to extension, so that on final completion of the building the switchboard will consist of about twelve panels centrally located.

From the switchboard to the low-tension delta at the transformers 500,000 cm. varnished cambric, lead-covered three-conductor cable in conduit, was used, and 300,000 cm. lead-covered three-conductor, 3,000-volt cable, from the generator to the switchboard. The transformers and switchboard equipment, including lightning arresters, was supplied by the Canadian General Electric Company.

Transportation.—All of the power plant equipment was brought from Kamloops to the Barriere by the C.N.P. Railway, and was hauled in to the plant over a government road a distance of about five miles.

Transmission Line.—The length of the transmission line from the Barriere generating station to the sub-station at Kamloops is 43 miles, and with the exception of two stretches of about eight miles each, the line passes through a comparatively open country parallel to the C.N.P. Railway line with overhead crossings.

It follows as much as possible on the river side of the railway to avoid future crossings when supplying power for irrigation. The poles are of cedar, varying in length from 40 to 50 feet generally, and are fitted with wooden cross-arms designed with the view to a two-circuit line at some future time. These poles were obtained near the line of the C.N.P. Railway, about thirty miles north of the Barriere.

[Note—For description of Kamloops steam turbine stand-by plant, see *The Canadian Engineer*, November 5th, 1914, issue.—Editor.]

LETTER TO THE EDITOR.

The Fetish of Overhead Power Transmission.

Sir,—Why is it that with the constant recurrence of interruptions to their systems, almost mainly due to the adoption of overhead wires, underground cables have not come in for their share of consideration?

With every puff of wind that springs up, heavy surging sets in on the system and very often dislocates one or other of the sub-stations, be it important or otherwise. During the gale which blew on or about the 12th of last month in Toronto and district the writer was informed there were no less than 18 interruptions in 24 hours upon the hydro-electric system of this city, some of quite a lengthy period from a business point of view.

Such a state of things would not be tolerated by any well-managed large industrial concern, where there were a number of employees at work, as these interruptions would upset factory routine and discipline. Now the overhead system has been fairly tried out, and it certainly seems to be found wanting.

There are obviously only two ways to secure continuity of supply—one by having a standby plant at the termination of the main trunk cables. I believe such has been or is being contemplated by the hydro-electric commission, whilst the Toronto Electric Light Co. already have such a plant. It is, however, very questionable whether a scheme of this nature be profitable, for when one considers the enormous capital sunk, and the large standby losses entailed, it would seem to be doomed to failure.

The second method, and one which, I think, merits serious consideration, is by the adoption of underground cables. It may be asked, "Are these any more reliable than overhead wires?" For answer one has only to refer to European practice, where there are thousands of miles of paper insulated cables laid, some working under the most adverse conditions, yet in the large cities, where the laying of the cables has received proper attention, a failure is almost unheard of, and where they have arisen, it has been due to faulty connections, of which a great number naturally must exist in city distribution. There should be none of these on trunk feeder mains, and when once properly laid they should form the strongest link in the chain between the water-wheels and the consumer. It is true that the voltages in use in Europe on these underground cables certainly have not reached the pressures in vogue in this country on overhead systems, but owing to the distances of transmission being much shorter, no demand has arisen for cables to withstand these very high potentials.

The writer, therefore, believes it is now time the cablemakers got busy and showed what they are capable of doing in this direction. This is essentially a country of paper, and as this when suitably impregnated has been found one of the cheapest and at the same time best dielectrics for cables, there is no reason why they could not be constructed to withstand the high voltages now in daily use. The principal factor, therefore, from the cablemakers' point of view, would appear to be one of "cost of cable, plus cost of laying."

Now, if the cost of concrete foundations, steel structure, porcelain insulators, etc., of the present system of overhead constructions be added to that of equipping a modern, up-to-date power station at terminal point, and if the cost of maintenance, together with the running expenses of the power station, be capitalized and also added, I believe it would be found to give a figure so high as to enable the underground cable to compete. Most of the cablemakers' work would be done in factories and by automatic machinery, so that there would only be the necessary trenching and filling to be done on site, and with modern trench excavators this could be done both quickly and cheaply. I trust that the cablemakers will go fully into the matter, and see what they can do.

HARRY F. CLAYTON.

Toronto, June 9th, 1916.

ORDINANCES TO CONTROL THE USE OF SEWERS.*

SECTION 1240 General Code of Ohio requires that plans for proposed sewerage systems shall be submitted to and receive the approval of the State Board of Health prior to their installation. In passing upon such plans it has been the practice of the State Board of Health to attach a condition of approval requiring the council of the municipality to pass a suitable ordinance defining the proper use of sewers for the purpose of preventing the installation of improper connections and misuse of the sewers.

In many communities storm water sewers are installed in advance of sanitary sewers and quite frequently the storm sewers are misused to receive sewage. This results in nuisances caused by odors emanating from the sewers and by objectionable conditions at the outlets. Storm water sewers are not designed to serve for sanitary purposes and municipal councils should adopt a suitable ordinance to prevent such misuse.

Sanitary sewers are frequently misused to receive rain water from the surface or from cistern overflows and downspouts. Such sewers are designed for conveying sewage only and the addition of surface water results disastrously in overtaxing the sewers. The excessive flow is also detrimental to sewage treatment works as it exceeds the capacity for which such works have been designed. To secure the greatest benefits from sanitary sewers, care should be exercised by those officials in charge of the maintenance of such improvements to require the proper use of the same.

The appended ordinances properly control the use of sewers and the establishment of connections thereto. In any individual case the ordinance to be adopted may require some modification to meet local conditions, but in the principal features relating to the classes of wastes which may be discharged into sanitary and storm water sewers, the ordinances should not be modified. The State Department of Health will upon request furnish advice in individual cases.

An Ordinance. No. ....

Mr. ....

To Regulate the Use of Storm Water Sewers.

Be it ordained by the council of the village of ...., State of Ohio.

Section 1. That before any connection can be made to any storm water sewer constructed in whole or in part by the village of .... a permit shall be secured by the person or persons by whom the connection is to be made. Application for permits shall be filed with and permits shall be issued by the village clerk.

*Ohio Public Health Journal.

Section 2. Sewage, including wastes from water closets, sinks, bath tubs and laundries, industrial wastes and other wastes objectionable because of appearance, odor or composition, shall in no case be discharged into storm water sewers. Cellar floor drains shall not be connected to storm water sewers. Cesspools or privy vaults shall not discharge into or be connected to a storm water sewer.

Section 3. Surface water, rain water from roofs, subsoil drainage, cistern overflows, clean water from condensers, and any other clean and unobjectionable waste water shall be discharged into storm water sewers.

Section 4. The village clerk shall inquire into and ascertain the purpose of all connections for which permits are requested and the permit issued shall definitely state the permissible use of the connection in accordance with Sections 2 and 3 of this ordinance.

Section 5. All connections in violation of this ordinance shall be abandoned and removed within two months after this ordinance takes effect.

Section 6. Whoever violates any provision of this ordinance shall be fined not less than five or more than fifty dollars and shall pay the costs of prosecution; and any person who shall make an illegal connection to a storm water sewer shall, if ordered by the health officer, remove such connection and if this is not done within five days, the health officer shall cause such connection to be removed and the expense thereby incurred shall be paid by the offending person. In default of such payment for a period of thirty days the said expense shall be certified to the county auditor to be assessed against the property for which the connection was made.

Section 7. All ordinances or parts of ordinances in conflict or inconsistent with the provisions of this ordinance are hereby repealed.

Section 8. This ordinance shall take effect and be in force at the earliest time allowed by law.

Passed .... 19.....

Signed ....
Mayor.

....
Clerk of Council.

An Ordinance. No. ....

Mr. ....

To regulate the use of sanitary and storm water sewers, to provide for the operation and maintenance of sewers, pumping station and sewage treatment works and to provide for the appointment of a superintendent of sewers and sewage treatment works.

Be it ordained by the council of the village of ...., State of Ohio.

Section 1. That before any house sewer can be constructed, or any connection can be made to any sanitary sewer or any storm water sewer constructed in whole or in part by the village of ...., permit shall be secured by the person or persons by whom the sewer is to be constructed, or the connection is to be made. Application for permits shall be filed with and permits shall be issued by the superintendent of sewers hereinafter provided for.

Section 2. A connection to a sanitary sewer or a storm water sewer shall not be made except by licensed plumber or a licensed sewer tapper and no such connection or the trench in which the drain is laid shall be covered or filled until the work has been inspected by the superintendent of sewers.

Section 3. The issuing of permits shall be governed by the following rules:

Sewage, including wastes from water closets, sinks, bath tubs, laundries, and other objectionable wastes shall be discharged into sanitary sewers and in no case into storm water sewers.

Cellar floor drainage shall be discharged into sanitary sewers.

Industrial wastes shall not be discharged into a storm water sewer but may be discharged into a sanitary sewer if the waste is of such character as not to be detrimental to the sewers or to the sewage treatment works. Where such wastes are detrimental to the sewers or sewage treatment works they shall be otherwise disposed of in a satisfactory manner or so improved in character as not to be detrimental to the sewer system or sewage treatment works.

Surface water, rain water from roofs, subsoil drainage, cistern overflows, clean water from condensers, and any other clean and unobjectionable waste water shall be discharged into storm water sewers and in no case into sanitary sewers.

Connections with cesspools or privy vaults shall not be made into sanitary or storm water sewers.

Section 4. All connections in violation of this ordinance shall be abandoned and removed within two months after the completion of the sanitary and storm water sewer system and sewage treatment works.

Section 5. The sewage pumping station and the sewage treatment works shall, from and after completion, be maintained and operated in a satisfactory manner at all times.

Section 6. Prior to the completion of the sewer system and sewage treatment works and before any connections to the sewers are permitted the mayor shall appoint a competent person as superintendent of sewers. The superintendent so appointed shall be charged with the care, maintenance and operation of the entire sewer system, the sewage pumping station and sewage treatment works. He shall issue the permits and make the inspections heretofore provided for and shall perform such duties in relation and pertaining to the provisions of this ordinance as council may direct. He shall give bond in the sum of five hundred dollars, with sureties approved by the mayor for the proper performance of the duties of his office. The superintendent of sewers shall receive a compensation of .... dollars per annum payable from the .... fund.

Section 7. Whoever violates any provision of this ordinance shall be fined not less than five or more than fifty dollars and shall pay the costs of prosecution and any person who shall make an illegal connection to a sewer shall, if ordered by the superintendent of sewers, remove such connection and if this is not done within five days the superintendent shall cause such connection to be removed and the expense thereby incurred shall be paid by the offending person and in default of such payment for a period of thirty days the said expense shall be certified to the county auditor to be assessed against the property for which the connection was made.

Section 8. This ordinance shall take effect and be in force from and after the earliest time allowed by law.

Passed by Council ....

Signed ....
Mayor.

Attest ....
Village Clerk.

Editorial

NON SIBI, SED PATRIAE.

In the last Weekly Bulletin issued by the Department of Trade and Commerce, Sir George E. Foster voices an appeal for the co-operation of various public bodies, including engineering associations, in the practical solution of the problems which will undoubtedly confront us as a people after the war is ended. While it is questionable how soon the war will end, there can be no question as to the wisdom of bringing to bear on this important subject the best intellects that can be found in the country.

Unusual conditions are bound to prevail immediately following the cessation of hostilities, when between fifteen and twenty million men will lay down their arms and flood factory, office and field. In addition, thousands of men who have been strenuously engaged in the production of munitions of war, will be thrown out of employment and will have to look for work in other lines. In view of these facts there is an urgent demand that leaders in all branches of industry, commerce, engineering and finance get together and, in a spirit of service, deal with these problems in a statesmanlike manner.

The engineer, who up to the present has been over-modest so far as his part in the direction of national affairs is concerned, must in the future "find himself" in a far larger degree. By reason of his training and talents he is well able to measure up to what can reasonably be demanded of him in the effort to work out satisfactorily the problems which will follow the war. This war has brought the engineer suddenly to the front—he must stay at the front, even after the war is over. Not only on the firing-line, but in the industrial organization back of the world-struggle the genius of the engineer is seen everywhere.

Surely, in view of the fact that the war has been almost entirely determined by engineering principles, it is not too much to expect that after it is over the engineer should do his part in helping to solve the great reconstruction problems, both abroad and at home.

It is most desirable that the engineering profession should have an important part in the programme outlined in Sir George E. Foster's circular, and it is to be hoped that engineers, individually as well as collectively through the various technical societies to which they may belong, will accept the challenge and contribute their quota,—not for their own personal benefit, but for the good of their country.

UNDERGROUND POWER TRANSMISSION.

On another page of this issue there is a letter from Mr. H. F. Clayton, which he entitles "The Fetish of Overhead Power Transmission."

We assume that Mr. Clayton has in mind the laying of underground cables from Niagara Falls to the various manufacturing centres in Ontario. Theoretically, the idea is good, and Mr. Clayton's letter may stimulate research work in that direction. Practically, however, the suggestion is considerably ahead of the times, and must await the production of a dielectric that will stand up under pressures up to 100,000 volts a.c. before underground construction for high voltages could compete with overhead line construction in either cost or efficiency.

A short length of cable is being operated in Switzerland at 40,000 volts a.c., but with that exception no cable has yet been designed, so far as *The Canadian Engineer* can ascertain, to withstand a working pressure over 33,000 volts a.c.

Several years ago a prominent Canadian hydro-electric engineer considered the possibility of constructing a 44,000-volt, three-phase cable for a comparatively short portion of a transmission system. But, we believe, he could not find a manufacturer who was prepared to submit a price and install the cable under a guarantee.

LETTER TO THE EDITOR.

"Another Water Powers Investigation."

Sir,—I note in your issue of June 1st, an editorial entitled "Another Water Powers Investigation," which, I think, does less than justice to the work of the Commission of Conservation.

In 1910, one of our engineers, Mr. A. V. White, examined all the powers in the province and in Nova Scotia. In New Brunswick, he examined all the powers except on the Restigouche and Upper Miramichi and procured data from other sources respecting the latter.

In Quebec, our hydro-electric engineer, Mr. Leo Denis, examined many powers and procured data respecting others from the engineers of the hydro-electric companies and others.

In Ontario, we utilized the comprehensive reports of the Hydro-Electric Commission and Georgian Bay Canal Survey.

The foregoing were all published in our "Water Powers of Canada," 1911, which also included the available data respecting water powers in Prairie Provinces and British Columbia.

Since 1911, Mr. Denis has examined the rivers to the east of Lake Winnipeg and the Nelson, Hayes, Upper Churchill, Athabaska, Peace and other rivers in Manitoba, Alberta and Saskatchewan. As the Winnipeg and Saskatchewan and their tributaries had already been examined under the direction of Mr. J. B. Challies, he courteously agreed to supply the data re these streams. The foregoing have been incorporated in our report on "Water Powers of the Prairie Provinces," which will be issued to the public at an early date.

In British Columbia, Mr. A. V. White has been engaged in field examinations for three years, and has prepared an exhaustive report, which is now in the hands of our editorial staff. It covers the field in great detail, and, like the two above-mentioned reports, will be authoritative for many years.

JAMES WHITE,

Assistant to Chairman, Commission of Conservation.

Ottawa, Ont., June 2nd, 1916.

PERSONAL.

HENDERSON & TAYLOR were recently appointed municipal engineers at Matsqui, B.C.

DON. E. LESLIE, Sarnia, Ont., has been appointed manager of the Sarnia hydro office.

G. B. RYAN, who has been chairman of the Water Commission at Guelph, Ont., for the past eight years, has resigned

HECTOR SOMERVILLE PHILIPS, A.M.Can.Soc. C.E., of Toronto, has been elected an associate member of the American Society of Civil Engineers.

H. A. BRECKENRIDGE, formerly with the Montreal Locomotive Work, Montreal, has become purchasing agent of the Lima Locomotive Corporation, Lima, Ohio.

ANDREW A. KINGHORN, C.E., Toronto, has been appointed by the Provincial Government to supervise the construction work of the Toronto-Hamilton Highway.

T. C. DUNCAN, E.E., for many years electrical superintendent of the public utilities of the city of Prince Rupert, B.C., has resigned that position to engage in private consulting work in the same city.

R. M. WILSON, chief engineer of the Montreal Light, Heat and Power Company, contributed a paper on "Frazil" at the convention of the National Electric Light Association, recently held at Chicago. P. T. DAVIES, of the power sales department of the same company, was among the Canadian delegates.

SIR WILLIAM PRICE, chairman of the Quebec Harbor Commission, has resigned owing to war obligations. Though not authentic, it is reported that Mr. D. O. L'ESPERANCE will be appointed as Sir William's successor, and that Mr. J. G. SCOTT will represent the English-speaking element on the Commission.

OBITUARY.

Lieut. TRAFFORD JONES, who practised as a civil engineer in and about Toronto for some eight years and enlisted last May with the Canadian Army Service Corps, met his death near Ypres during an aerial battle with German aviators. He was 29 years of age.

Lieut. C. S. D. ROSS, of Calgary, who was recently killed in action at the front, came to Canada from Cheshire, England, and was for some time engaged as civil engineer with the C.P.R. He left with a Calgary engineer battalion early in the war, and had been in the trenches for over a year.

CANADIAN SOCIETY OF CIVIL ENGINEERS, ELECTIONS AND TRANSFERS.

At a meeting of the council of the Canadian Society of Civil Engineers, held on May 23rd, the following elections and transfers took place:—

Members—Francis Blossom, New York City; David Albert Molitor, Toronto.

Associate Members—Hugh Ross Mackenzie, Regina, Sask.; Walter Matheson, Montreal; George Gilbert McEwen, Ottawa.

Juniors—Trevor Eardley-Wilmot, Montreal; Duncan Harold Macdonald, Antigonish, N.S.; John Randall Roberts, Montreal.

Transferred from Associate Member to Member—Samuel Bruce McConnell, North Bay, Ont.

Transferred from Student to Associate Member—Francis Xavier Ahern, Quebec, David Howard Fleming, St. Catharines, Ont.

COMING MEETINGS.

The Western Canada Irrigation Association will hold its convention at Kamloops, B.C., July 25th, 26th and 27th, 1916. The list of speakers already secured for this convention insures a very profitable conference. Among these are the following. Don. H. Bark, chief of the irrigation investigations, Canadian Pacific Railway, Strathmore, Alta.; J. C. Dobson, chairman, Hydro-Electric Co., Kamloops, B.C., who will speak on "The Possibilities of Irrigation by Hydro-Electric in the Thompson Valley"; William Young, comptroller of water rights, British Columbia, Victoria, B.C., on "Irrigation District Acts."

HYDRATED LIME IN CONCRETE PAVEMENTS.

(Continued from page 634.)

The percentage of wear decreased throughout both series with the increase of lime content. Contrary to the results obtained in the other tests, the resistance to wear increases past the points at which the highest values were obtained for tensile strength, compressive strength, and toughness. The increase is, however, not so rapid beyond these points in either series.

Conclusions.—The results of tests described above would indicate a certain marked advantage resulting from the addition of hydrated lime to Portland cement mortars. As well as an increase in the various properties determined there is the additional advantage that the material is more easily handled when the finished surface is developed, trowelling being easier than when the lime is absent.

From a close observation it would appear that there was no decided chemical reaction between the lime and the other contents of the mixture. Apparently the lime acts as a void filler, giving a more dense mixture and increasing the sand carrying capacity of the cement. If a high calcium lime were used there might be a certain limited reaction between it and the silicates of the cement.

From a comparison of the results obtained by other experimenters and those obtained by the writer it would appear that the least percentage of lime that would give the best results will vary with the grading of the fine aggregate.

A study of the accompanying curves will show that the variations in the different properties bear a close relation to each other. This indicates that the material is generally benefited by the addition of the proper proportions of hydrated lime.

The above determinations can only be called of preliminary importance. They indicate the percentage of lime that gives, approximately, the best results. A further series of tests of mortars with lime contents of 6 per cent., 7 per cent. and 8 per cent. for 1 : 2 mortars, and 14 per cent., 15 per cent., 16 per cent. and 17 per cent. for 1 : 4 mortars would show within one per cent. where the maximum strengths were developed.

Volume 30. Toronto, June 22, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

NOVEL THEORY APPLIED TO DIFFICULT FOUNDATION

PAPER PREPARED FOR THE CANADIAN SOCIETY OF CIVIL ENGINEERS, DESCRIBING THE METHOD EMPLOYED IN DESIGNING FOUNDATIONS FOR THE FEDERAL LEGISLATIVE PALACE IN MEXICO CITY.

By **SIFROY JOSEPH FORTIN**, Mem.Am.Soc.C.E.,
Chief Engineer's Branch, Department of Public Works of Canada, Ottawa, Ont.

IN designing the foundations of the Federal Legislative Palace now being built by the Mexican Government in the city of Mexico, the novel assumption was made that the bearing capacity of the subsoil gradually decreases from the perimeter towards the centre of gravity of the structure.

The building is 420 feet long, 370 feet wide, and in a general way it is composed of three stories and a basement; the highest part of the steelwork in the dome is 221 feet above the foundation.

Work was begun in 1905, after many preliminary experiments rendered necessary owing to the unreliable bearing capacity of a heterogeneous subsoil. The consolidation of the ground, to which we will refer later, was finished in 1910 and the erection of the steel structure was started in April of the same year. Due to the political troubles since 1910, work on the structure has been entirely stopped since the summer of 1913. If the work is carried out according to the original design it will cost over $12,000,000.

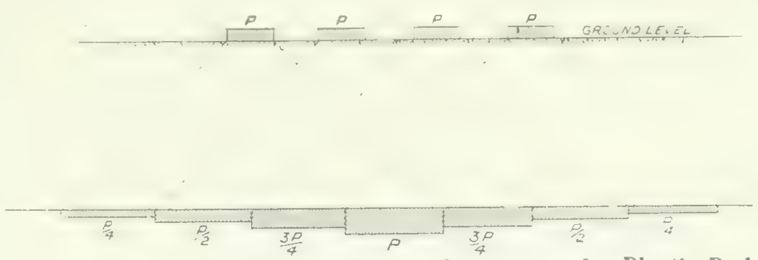


Fig. 1.—Illustrating the Variation of Resistance of a Plastic Body from the Edges to the Centre of a Foundation.

The design of the superstructure, which is of the well-known type of steel skeleton, though very complicated, did not present any unusual problem, but the foundations were designed according to a new theory. The usual way of designing foundations is to assume that the subsoil has a uniform resistance and, therefore, it is loaded at a uniform pressure per unit of surface; the contrary idea prevailed in designing the foundations of the Palace, for the capacity of the subsoil to resist pressure was assumed to gradually decrease from the perimeter towards the centre of gravity of the building.

The greater part of the city of Mexico is built on the site of an old lake called Texcoco, whose elevation is 7,400 feet above sea level. Mountains surround the Valley of Mexico, one of which, the Ajusco, rises 13,000 feet above sea level. The site of Mexico City is the lowest part of the valley and for ages volcanic ejections, alluvial matter, etc., have been washed down into the valley from the mountain sides. At the Palace site the soil is composed of a layer of filling matter, debris, dust, etc., about seven feet thick; underneath comes a very peculiar and unique substance. It has the appearance of clay and lies in alternate beds of various thicknesses of brownish and reddish color. That substance is as soft as butter and some of it emits a peculiar smell as of decomposed vegetable matter. It is mixed in various proportions with volcanic ejection or sand.

From time to time one comes across a thin layer of sand and occasionally we meet a pocket which no doubt was originally filled with water. This substance weighs sometimes as little as 70 pounds per cubic foot; that is to say, some 10 to 15 per cent. more than pure water. When this substance is taken out of the ground, the water cannot be squeezed out by pressure, but if left exposed to the atmosphere and to the sun, it loses from 41 to sometimes 82 per cent. of its volume, becoming a gritty lump. This subsoil has an unknown depth, artesian wells 800 feet deep having been bored without finding bed-rock, though occasionally the drill meets boulders of various sizes.

This clayey material cannot support even a light load without deformation. When the steel for the structure arrived at the site it had to be spread evenly on the ground, otherwise uneven settlement was immediately observed. In all constructions of any importance the walls have to be carried up level in order to avoid uneven sinking. It can be judged from this that foundations in Mexico City are a very delicate problem. Almost all the buildings in the city are out of level and out of plumb.

The most peculiar thing, however, in connection with foundations in Mexico is that the centre of the buildings almost invariably sinks more rapidly than the perimeter; not only that, but the elevations, if of any length, say, 75 feet long or longer, invariably sink more in the centre than on the ends, taking a concave form.

The engineer in charge of the foundations for the Federal Legislative Palace was Senor Gilberto Montiel, who was also at that time Deputy Minister of the Department of Public Works. Senor Montiel was fully aware of the bad quality of the subsoil of Mexico and particularly of the fact stated above, that all foundations sink more in the centre than on the edges. He looked about for an

explanation of this evil and it occurred to him that the subsoil of Mexico, under a load, was acting more like a semi-solid or plastic body than like a solid material. After long researches, he found that Rankine had studied this problem in his Manual of Civil Engineering and Applied Mechanics. He also found the entire theory of the resistance of a semi-solid body to pressure in a book called "Théories des Potentiels," by Boussinesq, a French author.

The theory proves that the resistance of a semi-solid body to pressure varies from the perimeter towards the centre as the co-ordinates of an ellipse. The variation of resistance of a plastic body from the edges to the centre of a foundation can also be illustrated graphically. (See Fig. 1.)

We have assumed that the pressure due to a load follows an angle of friction of 45 degrees, but any other angle will give similar results. On the sketch we have taken into consideration four equal loads placed at equal intervals. It is seen that the pressure on the soil decreases from the centre towards the ends because, as we go down the loads merge one into the other, the pressure per unit of surface in the centre in this case and at a given depth being four times the pressure near the ends. When we

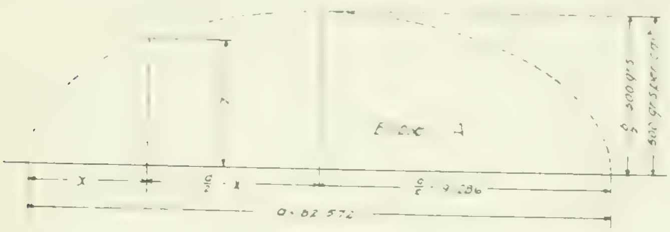


Fig. 2.—Ellipse A.

a = 182.572 $\qquad$ a^2 = 33,332.34

b = 1,000 $\qquad$ b^2 = 1,000,000

$$\frac{y^2}{b^2} = \frac{x(a-x)}{d^2}$$

deal with good foundation material this effect is not noticed because a material which can resist a certain pressure per unit of surface without deformation will equally resist one-quarter of the same pressure; but, when we deal with semi-solid material or such subsoil as we find in Mexico, we recognize immediately that a pressure of one-quarter of a given load will produce less effect than the entire load will. It has occurred to us that if the concave effect is not oftener noticed in construction on weak subsoil it is because walls well built may act as a beam or perhaps as an arch in certain instances.

In preparing the foundation for the Palace, Senor Montiel first excavated a hole four feet below the street level, thereby removing part of the filling. After that, a cofferdam was built surrounding the entire site, said cofferdam being of reinforced concrete five feet thick and extending 24 feet below the floor of the excavation.

Then Senor Montiel proceeded to consolidate the ground; that is to say, to increase its bearing capacity. To accomplish this he drove sand piles in the bottom of the excavation; or, to express it more correctly, he drove holes eight inches in diameter from 10 to 14 feet deep and 20 inches centre to center and proceeded to fill these holes with sand which again was pressed into the ground, pressed down by the pile; the hole was then again filled with sand which again was pressed down into the ground, the operation being repeated two, three and sometimes four times. One hundred and fifty thousand of these sand piles were driven in or injected into the ground, and to give an idea of the quality of this ground, we will say that the holes were made with a wooden pile driven in by a small pile-driver and the pile went in four to five feet at a single blow. Besides, enough sand was injected into the ground to raise the level of the pit five feet, whereas it was found that it only had been raised about one foot. Underneath heavy walls and heavy column loads, long wooden piles were driven in between the sand piles.

After this work was finished, a bed of loose broken stone about one foot thick was provided, covering the entire surface within the cofferdam. The loads brought on the foundations by the columns and walls were spread out by means of steel grillages. Under each grillage was placed a bed of concrete 20 inches thick, but these beds were isolated and not continuous though, naturally, sometimes these beds serve more than one column, depending on the necessities of the design.

The consolidation of the subsoil required two years of hard work, and no doubt the bearing capacity of the ground has been increased. Nevertheless, Senor Montiel thought that some sinking would still occur and consequently the structure was started four feet higher than required, to allow for expected settlement.

The assumption that the subsoil would still act as a semi-solid or plastic material was adhered to notwithstanding the consolidation, and consequently the ground was loaded unevenly, the unit pressure decreasing as the co-ordinates of an ellipse from the perimeter towards the centre of gravity of the building.

First it was assumed that the average uniform pressure that the ground could safely carry was 1,000 grams per square centimeter, equivalent to 2,048 pounds per square foot. Then it was decided that the pressure in the central zone, into which fell the entire foundation of the cupola, should be 1,947 pounds per square foot, and that the difference in pressure in adjoining zones should be 25 grams, equivalent to 51 pounds per square foot, so that in the second zone the pressure became 1,997 pounds and in the third zone, 2,048 pounds per square foot, etc.

Ellipse A was then constructed. For its semi-minor diameter we adopted 500 grams per square centimeter (1,024 pounds per square foot), or one-half of the average unit pressure, and for its semi-major diameter we adopted the distance from the centre of gravity of the building to the farthest corner of the cofferdam, or 299.51 feet. See Fig. 2.

It was then found that the dividing point between the first and second zones was at a distance of 93.51 feet from the centre of gravity of the building measured on the line running from the said centre of gravity to the corner of the cofferdam. Likewise the dividing point between the second and third zones is 130.55 feet from the same centre of gravity, etc. For a clearer conception of ellipse A it should be regarded as lying in a vertical plane passing through the centre of gravity of the building and the farthest corner of the cofferdam; the centre C of the ellipse coinciding with the centre of gravity and point D with the corner of the cofferdam. See Fig. 3.

Here the reader may well ask if ellipse A has been constructed in strict accordance with the theory developed and analyzed by Rankine and Boussinesq. The answer is that it has not. The researches of these authors cover cases of uniformly distributed loads, whereas at the Palace we have heavy concentrated loads very unevenly distributed. The selection of the major and minor diameters of ellipse A was arbitrary but served the object in view, *viz.*, to

have the unit pressure in the various zones decrease as the co-ordinates of an ellipse.

In the central zone the pressure is 1,947 pounds per square foot and in the zone in which the four corner columns of the structure stand, the pressure is 2,560 pounds. The extreme difference in unit pressures is therefore 613 pounds or, say, 32 per cent.

At this stage of our calculation we therefore had various points: 93.51, 130.55, etc., where the pressures were changing and had the building been as wide as it is long, we would have drawn circles passing through these points thus defining the pressure zones. But, the structure being longer than broad, we determined on ellipses for defining the zones. These ellipses, which we call B (see Fig. 4), have all the same centre which is the centre of gravity of the building, have their major diameter coinciding with the longitudinal axis of the building and their minor diameter running along a transverse axis passing through the centre of gravity of the building. This centre of gravity lies 17.39 feet west of the centre of the dome.

Ellipses B lie in horizontal planes, pass of necessity through the dividing points 93.51, 130.55, etc., as determined by ellipse A, and finally their minor and major diameters have the same relation as the width of the building has to its length, *viz.*:

$$\frac{370}{420} = 0.88$$

There remains now only to develop the formulas shown below Fig. 4.

By calculating the area of each zone and multiplying it by its corresponding pressure, we found that the average pressure within the cofferdam was 2,136 pounds per square foot instead of 2,048 pounds, which we had assumed. The error of 4 per cent. being small we disregarded it, though had we been able to reduce all the unit pressures by 102 pounds we would have done it, but it was impossible to do so because the foundation of the dome proper would have encroached on the adjoining beds, thereby upsetting the entire system. Besides, had we reduced the unit pressure, the space within the cofferdam would have been too small to carry the building. Nor did the architect think advisable to reduce the weight of the structure. It should be said here that the cofferdam was built before the total weight of the building was figured and before the system of uneven unit loading was adopted.

Unfortunately, we cannot at present judge whether or not the theory of uneven unit pressure will fulfil our expectation, because the walls have not yet been started. All that can be said is that with the very small loads now on, the foundations have settled, and parts of them unevenly, but this does not prove against the theory because the present loads have no relation to the calculated ones.

The problem of a proper foundation in that part of Mexico City formerly covered by the Lake Texcoco is yet unsolved. A great many buildings, old and modern, have the concave appearance referred to above, but sometimes a corner will sink more than the rest of the structure, showing that the subsoil is not homogeneous. The southwest corner of the Cathedral, built 300 years ago, is four feet lower than the southeast corner. The northwest corner of the National Theatre, now in course of construction, has sunk four feet and four inches in four and a half years; in the same period the northeast corner has sunk only two feet and ten inches. No provisions were made in this building for settlement, with the result that it already looks low and leans on one side. The School of Mines Building, which is one of the oldest and finest in the city, is badly cracked and in some parts in danger of collapse. At the Federal Legislative Palace the subsoil at the southwest corner shows signs of being weaker than any other place within the cofferdam. Indeed, at that place there exists an area of soft subsoil extending one or two blocks westward; other areas of soft subsoil exist within the city where the streets, originally level, are now depressed sometimes as much as three feet.

For the better conception of the problem of foundations in Mexico City, it should be noted that, as stated above, part of the site of the present city was originally under water. Gradually the water receded, but until twenty years ago the lowest parts of the city were subject to periodical floods during the rainy season, and the water level at normal times was almost up to the level of the streets. Twenty years ago a sewerage system and a drainage canal were built by a British firm with the result of eliminating the floods and of lowering the water level throughout the city; we now find water at from three to ten feet, according to location.

In drying up, the ground has shrunk. This shrinking of the ground certainly contributed to a certain extent

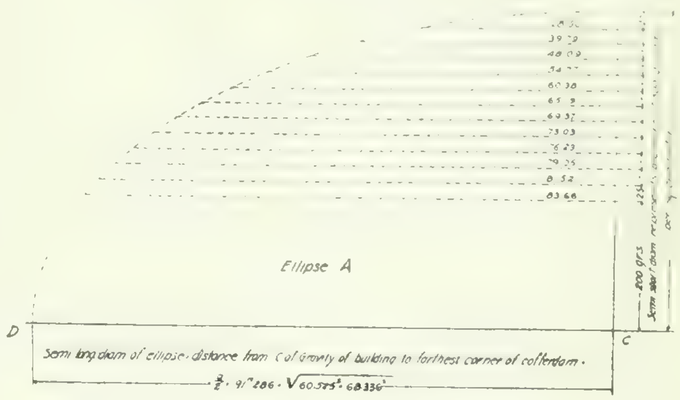


Fig. 3.—Ellipse A.
(Measurements are expressed in meters.)

to the sinking of the houses, but in our estimation the principal element causing the buildings to settle and become out of plumb is the unsatisfactory and unreliable clayey subsoil described above as evidenced by the fact that new buildings, whose foundations are carried below water level, are also sinking more or less rapidly, and as a rule more rapidly than the old existing structures.

It is well proved by a large number of observations that the sinking is more pronounced during the dry season, lasting from November to June than while the rains last, that is from June to November.

Levels run to the rocky mountainside have shown that the City of Mexico as a whole is sinking at the rate of three-eighths of an inch a year.

Some Mexican engineers advocate the driving of piles for reinforcing the subsoil, while others claim that this method is not effective and may even become prejudicial. Examples are known of piles, driven during the day, shooting up during the night and damaging the ground. The writer has seen advocated lately the idea of temporarily loading the subsoil before permanent work is commenced, thus causing an advanced compression and sinking of the ground. This idea, however, can only be carried out in special cases. Besides, we know of buildings 25 years old and more that are still sinking.

One engineer, Senor Angel Peimbert, lately advocated placing the foundations on the crust or present surface of

the ground, because the crust, made of debris, dust, etc., is of a different substance than the clayey matter underneath, and besides, it is already compressed to a certain extent. This method would not permit of building cellars, but otherwise it is practicable, there being no frost in Mexico; it might well be adapted to light and moderately heavy structures, because the crust and tepetate bed under have better resisting power than the clayey subsoil. It is evident, however, that notwithstanding any method employed to reduce or stop the sinking, efforts should be used to reduce the unit pressure to a minimum and, when dealing with important buildings covering large areas, tests should be made before permanent foundations are commenced.

Now, can the sinking be arrested, or at least retarded? We believe it can, and the best method we know is by injection, under pressure, of cement or cement and lime mixed, under or close to the foundation. With this method the sinking of a large store building in Mexico was entirely stopped. The method has also been used in connection with the National Theatre with great success. By injecting cement at the proper places, the uneven settle-

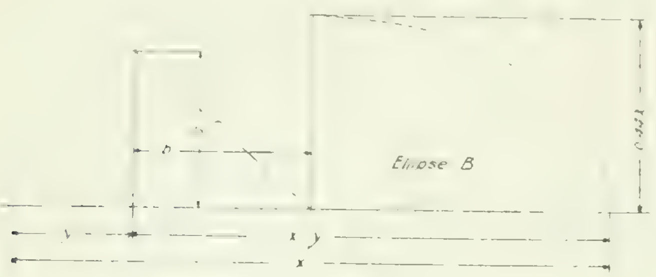


Fig. 4.—Ellipse B.

The length of the building is 127.37 meters, breadth 112.04. Long and short diameters of the ellipses B are in relation to the length and breadth of the building, or $\frac{112.04}{127.37} = 0.88$.

$$y \quad \frac{x}{2} \quad b.$$

$$b = 1.129\,a. \qquad b^2 \quad 1.2746\,a^2.$$

$$c = 1.5082\,a.$$

$$\frac{a^2}{0.88^2} = 1.2913\,a^2.$$

$$\frac{x^2}{0.88\,x^2} - y\,\frac{(x-y)}{a^2}$$

$$\frac{x}{2} \quad 1.062\,c.$$

ment has been stopped and the sinking of the entire structure greatly reduced; it was the intention of the Mexican government to continue the injections until the sinking had been entirely stopped.

The mode of operation is simply to make a hole in the ground with a pile driven by an ordinary pile-driver; to fill the hole, or at least place dry cement in the hole, and push the cement into the surrounding ground with the same pile. The cement coming in contact with water contained in the ground will set, thereby increasing the bearing capacity of the soil. Another system used was to push down the cement by hydrostatic pressure.

The metallic structure for the dome of the Federal Legislative Palace is completed and riveted. The present weight on this particular foundation is about 30 per cent. of the calculated load, and with this light load, notwithstanding the consolidation of the ground, the sinking in two years amounted to sixteen inches. Levels were taken monthly and they showed that the sinking was very even and, furthermore, strictly in accordance with Senor Montiel's prevision—so, to that date, the theory was upheld.

The steelwork for the Palace, as well as the foundations, was designed by engineers sent to Mexico by Milliken Bros., of New York, and placed under the writer's charge. All data, however, including the idea of uneven pressure on the foundation, was furnished by Senor Montiel, who alone could take such responsibility on behalf of his government. The foundations are necessarily heavy, due to the enormous weight of the building and to the low bearing capacity of the soil.

The dome is situated near the centre of the structure, and it is the principal feature of it architecturally as well as structurally. It rests on a continuous concrete foundation 150 feet long by 140 feet wide. The grillage weighs over 4,000 tons, consisting mostly of plate girders, of which there are 108, running the entire length and breadth of the concrete bed. Some weigh 50 tons, were fabricated in New York, and were shipped to Mexico City in three sections.

The superstructure of the dome weighs over 3,000 tons. There are plate girders 55 feet long, weighing 27 tons, at the base of the circular drum, which stands 120 feet above the foundation. These were brought from New York in one piece and raised to their final resting place by means of the erecting tower. Supporting these girders are four latticed trusses, one on each side, each weighing over eighty tons, but they came in pieces and were erected by means of falsework. The dome complete, including grillage, has been set by means of an erecting tower 50 feet square and about 200 feet high with one steel boom 70 feet long and of 30 tons capacity at each corner. This tower was set before any steel arrived, and also served to unload and handle the material. It was never moved, but twice we cut the corner posts at the bottom to allow the grillage girders to be erected.

RAILWAY EARNINGS.

The following are the railway earnings for the first week of June:—

Canadian Pacific Railway.

	1916.	1915.	
June 7	$2,674,000	$1,585,000	+ $1,089,000

Grand Trunk Railway.

June 7	$1,107,091	$ 959,977	+ $ 148,114

Canadian Northern Railway.

June 7	$ 629,700	$ 409,400	+ $ 220,300

The Traylor Engineering and Manufacturing Co., Allentown, Pa., has purchased control of the Cement-Gun Co., of New York. The head office has been moved to Allentown, and new officers elected as follows: S. W. Traylor, president; W. J. Roberts, vice-president; F. R. Crispen, secretary; H. Battersby, treasurer; and B. C. Collier, general manager.

The American-Russian chamber of commerce has received information that the Russian cabinet has decided after a conference in Petrograd, to make preparations for the construction of 25,000 miles of railroads in Russia within five years. The Russian ministers of agriculture, industry, commerce, finance and war participated in the conference, according to this information.

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS

A BRIEF REVIEW OF WATER RESOURCES PAPER No. 3, AN OFFICIAL PUBLICATION OF THE DOMINION WATER POWER BRANCH, COVERING THE DEPARTMENTAL INVESTIGATIONS INTO THE POWER RESOURCES OF THE WINNIPEG RIVER WATERSHED.

PART II.

THE reach of the river considered in the power studies, covered in Water Resources Paper No. 3, of the Dominion Water Power Branch, extends from Lake Winnipeg to the headwaters of the city of Winnipeg municipal plant at Point du Bois, and comprises practically the entire drop of the river in Manitoba. The river is, to a large extent, composed of deep, broad basins with but little current, broken by abrupt changes in level at the various falls and rapids. These pitches take place at, and are occasioned by, granite outcrops, which are invariably in evidence on both river banks and in the stream bed. At such points the bedrock as a rule forms a distinct ridge at a higher elevation than the bed of the river in the pond above, and is, in fact, the controlling features governing the level of the lake-like expanses. As a result, the drops are generally well concentrated, and the hydraulic gradient between the various falls and rapids is usually negligible, a combination of circumstances which renders possible the utilization for power purposes of practically the entire fall of the river.

Ice Conditions.—The northerly latitude in which the Winnipeg River is located necessitates a most careful consideration of possible ice troubles in the design of the hydro-electric plants along the river.

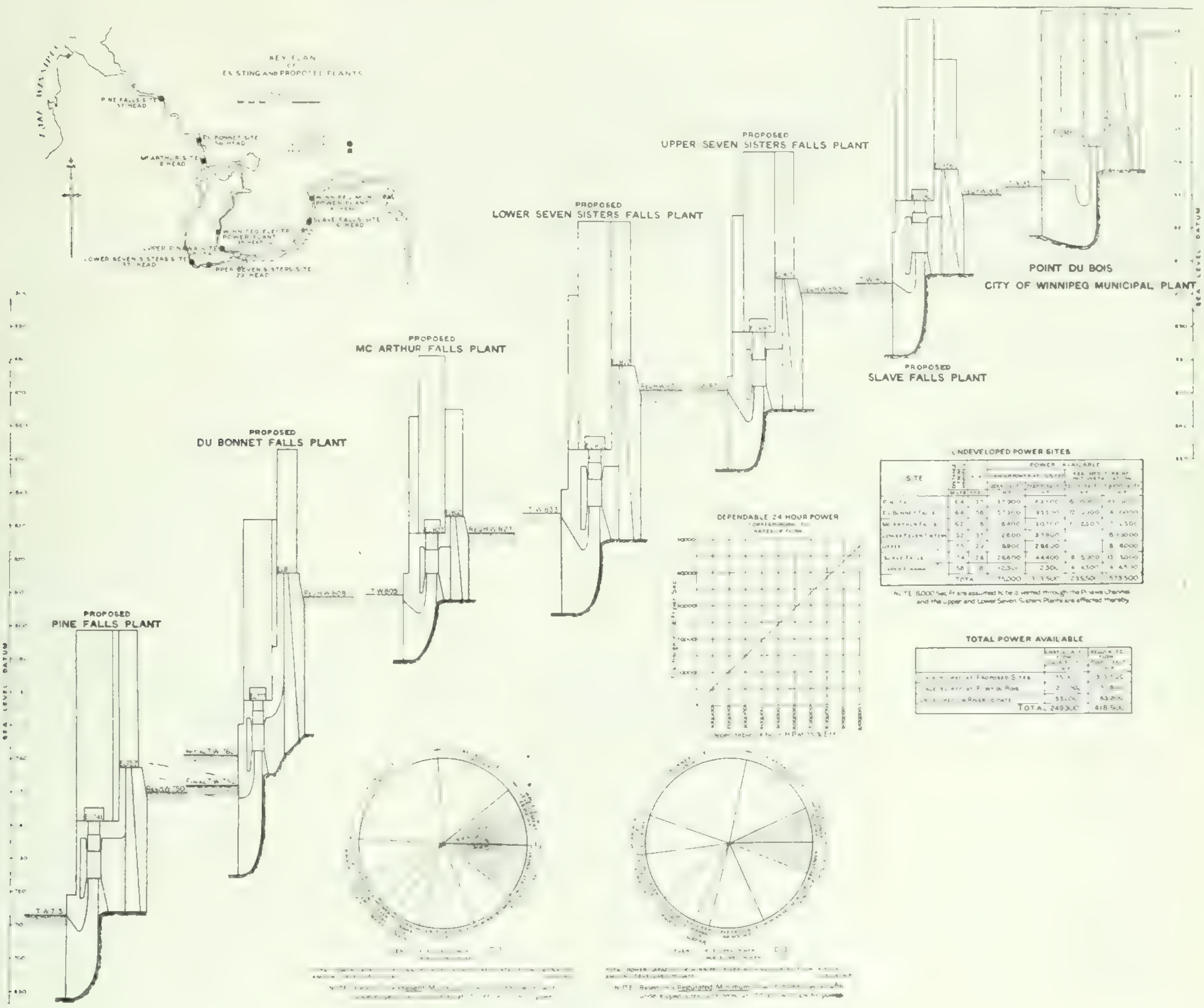


Fig. 1.—Key Plan.

In the layouts which have been designed for the development of the present unutilized head in the river, special attention has been given to the question of protection from ice troubles, and in none of the layouts proposed are they anticipated.

Foundation Conditions.—Unexcelled foundation conditions are assured at all the proposed plants. The natural granite formation which underlies the entire country is

exposed on the surface at all locations selected for hydro-electric development. At several of the sites the rock outcrops throughout the entire layout.

Head and Tailwater Elevations.—It is not intended in Water Resources Paper No. 3 to unchangeably fix the exact head and tailwater elevations of all the proposed

Grand du Bonnet Falls, Ice Conditions.

concentrations. These final elevations are dependent on full and complete surface level records under all conditions of discharge. Owing to the comparatively unsettled nature of a large portion of the river banks, it has been very difficult to secure satisfactory and regular gauge readers. As a result, on some reaches of the river, the surface level records under different stages are not as complete as is desired. This information is being secured as rapidly as possible, and will be available in sufficient time to deal with any questions of administration which may arise in connection with the development of the reach along the lines set out.

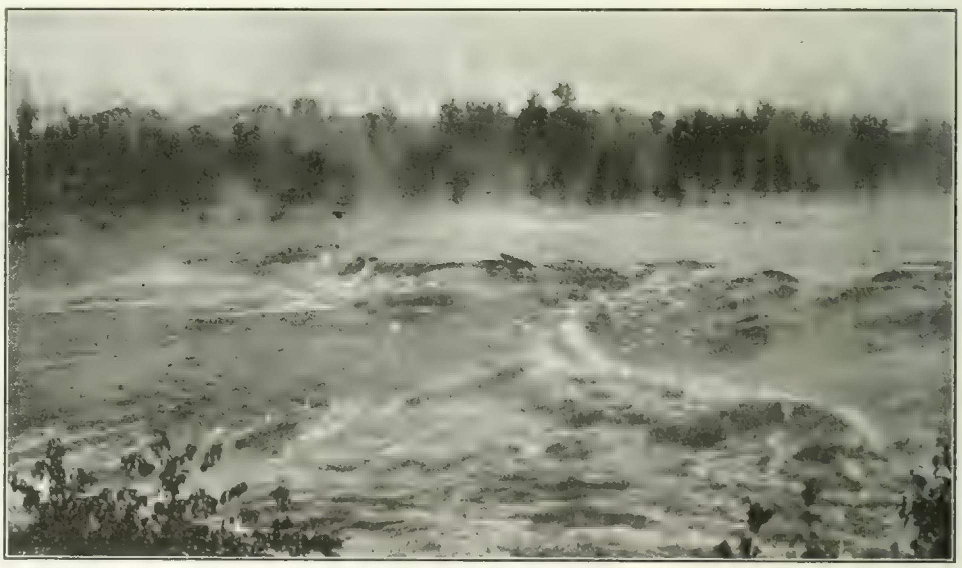
The head and tailwater levels as set out in the report are considered to very closely represent the final levels, and any variation which later information may necessitate should not change the present conclusions to any great extent.

General Basis of Design and Layout.—The submitted designs and layouts have been worked out in the head office in Ottawa on the general basis set out in the following, and have on this basis been approved by Mr. J. B. McRae, consulting engineer to the Dominion Water Power Branch. The designs of the power houses, dams and contingent structures, and the proposed hydraulic and electrical equipment, have been developed only in sufficient detail to permit making accurate estimates of the quantities and costs involved. It is not intended that the designs and layout proposed, and the equipment suggested, should be adhered to in all respects by any parties developing the power at these sites. It is intended, however, that the basic elements of the design be maintained as proposed, in the interests of the complete river development scheme. These basic elements are: Head and tailwater elevations, discharging capacity and stability of dams, and stability and sufficiency of power houses and contingent structures.

The layouts are designed for an initial and for a final installation. At points where the whole flow of the river is available for development, the preliminary installation is designed to utilize 12,000 second-feet (the present minimum flow of the river), with provision for the subsequent addition of sufficient units to properly care for a regulated flow of 20,000 second-feet. The latter is spoken of throughout the rport as the final installation.

The details of the designs, such as sections and plans of the power houses, dams, ice sluices, and embankments, etc., have been standardized throughout all the plants, varying according to the head and to the equipment at each site. In all cases, single-runner vertical turbines have been adopted. The purpose of this standardization of design is the desirability of having the cost of development at each site reduced to the same basis or measure in order that the comparative merits of the different projects can be ascertained.

Estimates of Cost.—The question of the advisability of publishing detail capital and operating cost estimates was at first debated, as it was felt that they might be open to criticism and that conditions changing with the passage



Pine Falls, Main Drop.

of time would possibly very materially alter the published figures. It was thought, however, that the advisability of supplying prospective users of power with some conservative and authoritative measure whereby the economic as well as the engineering merits of the various sites could be readily compared, and with which competing sources of power could be analyzed, more than outweighed other

considerations. To neutralize possible future criticism of the published estimates, care has been taken to supply in the report such plans and data covering each site as will enable independent estimates being made by any parties interested in its development.

The general costs quoted are based on a twenty-four-hour output, at 75% over-all efficiency, as this forms a uniform and, considering the more than 90% efficiencies claimed for modern turbine runners, conservative measure for comparison. The figures on this basis, scarcely do the developments justice, since in them no account is taken of peak loads and of the re-sale of power such as is always possible in plants projected for the supply of power for general industrial and lighting consumption. In all designs ample machine capacity has been allowed to care for all peak loads which can be reasonably expected, and to supply spare units for emergencies. This over-development has added largely to the estimated cost of the plants and hence to the unit cost when the latter is based on twenty-four-hour power. On the other hand, costs per horse-power, based on the installation, frequently convey erroneous ideas as to economic efficiencies, since local conditions or an auxiliary steam plant frequently permit the excessive over-development of a particular power site in proportion to the dependable power available from the river. However, in the designs and estimates considered, the machinery installed bears, in all cases, a definite ratio to the power in the river, and this ratio cannot be considered too high in plants handling normal industrial and lighting loads. The unit costs based on installation can, therefore, be profitably studied in conjunction with the unit costs on a twenty-four-hour basis.

In all cases provision has been made for access to the site by rail, or in the case of the Pine Falls plant, by water. In each case 10% has been allowed for contingencies, 5% on this total for engineering and inspection, and 5½% on the whole for one year for interest during construction.

The actual cost of the construction of the two existing plants on the river has been carefully studied and compared with the estimated costs of the various proposed developments. Independent estimates by private engineering firms have also been found to check closely with the capital costs submitted. The estimates may therefore be taken as setting out conservatively and closely the capital construction cost of the proposed sites.

As in the case of the capital costs, the annual operation costs have been estimated to a uniform standard, and hence form a measure whereby the commercial prospects of the different projects can be readily compared.

The operation costs include capital charges and are published in terms of cost per horse-power-year twenty-four-hour power; cost per horse-power-year machinery installed; cost per kilowatt hour at 100 per cent. load factor, and cost per kilowatt hour at 50 per cent. load factor. These costs represent the operating charges at the power station, and do not include transforming and transmission.

Table 1.—Undeveloped Power Sites on the Winnipeg River in Manitoba.

Site	Distance from Winnipeg in Miles	Head	Power Available: 24 Hour Power at 75% efficiency, 12,000 Sec. ft.	24 Hour Power at 75% efficiency, 20,000 Sec. ft.	Turbine Installation (units considered), 12,000 Sec. ft.	Turbine Installation (units considered), 20,0000 Sec. ft.
1	2	3	4	5	6	7
Pine Falls	64	37	37,900	63 100	6—10,000	10—10,000
Du Bonnet Falls ..	64	56	*57,300	95,500	*9—10,000	14—10,000
McArthur Falls	62	18	18,400	30,700	11— 2,500	17— 2,500
†Lower Seven Sisters	52	37	12,600	37,900	...	6—10,000
†Upper Seven Sisters	55	29	9,900	29,600	.	8— 6,000
‡Upper Pinawa	58	18	12,300	12,300	4— 4,500	4— 4,500
Slave Falls	74	26	26,600	44,400	8— 5,000	13— 5,000
		Total	175,000	313,500	235,500	473,500

NOTE.—* This tabulation assumes an initial development at the Du Bonnet site utilizing 12,000 second feet at 56 foot head.

† The Upper and Lower Seven Sisters sites are located in the main channel of the Winnipeg River paralleling the Pinawa through which 8,000 sec. ft. is assumed to be diverted for the operation of The Winnipeg Electric Railway Plant.

‡ The Upper Pinawa site is located on the Pinawa Channel.

Summary of Dependable Power.—A summary of the undeveloped power, as outlined in the above power studies,

Seven Sisters Falls, Third Fall.

together with the total dependable power on the river in Manitoba, including that developed to date, is appended in Tables 1 and 2.

Table 2.—Total Power Developed and Undeveloped on the Winnipeg River in Manitoba.

	Unregulated Flow 12,000 sec. ft.	Regulated Flow 20,000 sec. ft.
Undeveloped at proposed sites	175,000	313,500
Undeveloped at Point Du Bois	21,100	51,800
Developed on River to date ..	53,200	53,200
Total	249,300	418,500

NOTE.—Power in terms of 24 Hour Horse Power at 75% efficiency.

The above tables indicate that there is 53,200 horse-power developed to date, 196,100 horse-power undeveloped and available in times of present low water on the river, and 365,300 horse-power undeveloped and available when the river is regulated to a minimum flow of 20,000 second-feet. It must be borne in mind that these totals are given

in terms of twenty-four-hour power, and hence give a rather limited estimate of the river's resources. A translation of these totals into shorter range power will therefore prove of interest.

Table 3.—Dependable Power on Winnipeg River in Manitoba.

	Unregulated Flow 12 000 sec. ft.	Regulated Flow 20,000 sec. ft.
Twenty-four Hour Power	249,000	418,000
Twenty Hour Power	299,000	502,000
Sixteen Hour Power	373,000	627,000
Twelve Hour Power	498,000	836,000

The above tabulation shows the greater scope of the power resources to meet varying demand, but must only be applied with discrimination. What might be called the dependable commercial power available can be placed at well above the half-million mark.

Summary of Capital and Operating Costs.—The data respecting the estimates of the various schemes have been condensed into Tables 4 and 5 for the purpose of ready reference and comparison.

Table 4.—Estimated Capital Cost of Developing the Proposed Power Sites on the Winnipeg River in Manitoba. Power Placed on the Low-tension Switchboard in the Power Station.

Site	Capital Cost on low tension switchboard in Power Station: Total Cost 12,000 sec. ft.	20,000 sec. ft.	Per H.P. on Basis of 75% Efficiency 24 Hour Power 12,000 sec. ft.	20,000 sec. ft.	Per H.P. on Basis of Installation 12,000 sec. ft.	20,000 sec. ft.
1	2	3	4	5	6	7
	$	$	$	$	$	$
Pine Falls..........	3,057,000	4,407,000	80.66	69.84	50.95	44.07
Du Bonnet Falls....	*4,624,000	6,551,000	80.70	68.60	53.80	46.79
McArthur Falls.....	2,031,000	2,740,000	110.38	89.25	73.88	64.47
†Lower Seven Sisters.		3,409,000		89.95		56.82
†Upper Seven Sisters.		2,724,000		92.03		56.75
Upper Pinawa......	1,280,000	1,280,000	104.07	104.07	71.11	71.11
Slave Falls.........	2,327,000	3,436,000	87.50	77.39	58.20	52.86
Total...............	13,319,000	24,547,000				
Mean (based on power output)			87.30	78.30	56.60	42.80

*Proportional Capital Cost of development of 12,000 second feet at 56 foot head.

†Upper and Lower Seven Sisters Sites are not feasible of development until the river flow is more systematically regulated.

The Du Bonnet plant, in view of its high head, will prove the most economically efficient of the series, the capital cost per horse-power being $68.60, and the McArthur plant, in view of its low head and the long dam and headworks required, is actually the most costly as measured by the output, the cost being $89.25 per horse-power. The two Seven Sisters and the Upper Pinawa sites cannot be directly compared with the other four as each receives only a portion of the river flow, with a consequent comparative decrease in the power produced. However, under a regulated flow of 20,000 second-feet in the river their unit capital costs of $89.95, $92.03 and $104.07 respectively, will prove very attractive from a commercial viewpoint.

A consideration of the total costs shows the following: The total final output of the seven proposed developments is 313,500 horse-power at a total capital cost of $24,547,000, *i.e.*, an average cost of $78.30 per horse-power or $42.80 per horse-power based on machinery installed.

The annual operating costs are probably of greater interest than the above capital costs, and are summarized in Table 5.

The results tabulated in Table 5 bear out the general conclusions as to comparative economic efficiency that have been noted from a discussion of the capital costs. They are listed in terms of initial and final development, corresponding to present regulated run-off, respectively. The costs per kilowatt hour, considering a 50% load factor, as shown in column 11, indicate in all cases highly desirable commercial undertakings.

While the annual operation costs quoted may appear low, a review of the estimates and of the general underlying principles upon which they are based will establish the conservativeness of the conclusions. The figures represent operating conditions which possibly would not be met upon the immediate completion of the undertakings; that is to say, the initial market would possibly not warrant the initial installation proposed. This would result in higher initial capital and operating costs than are submitted above. At the same time, it would be a simple matter to present the unit costs published herein in a much more favorable light than has been done. Considering the ample pondage facilities which exist, the general run-off conditions of the river, and the general opportunities of an industrial market, twenty-four-hour power is a most conservative basis on which to establish final figures.

As illustrative of this, the Pine Falls site may be briefly considered. The continuous twenty-four-hour power available here is 63,100, and the annual cost per

Table 5.—Estimated Annual Cost of Operation of the Proposed Power Developments on the Winnipeg River in Manitoba. Power Placed on the Low-tension Switchboard in the Power Stations.

Site	Annual Operating Cost on low tension Switchboard in Power Station: Total Annual Cost 12,000 sec. ft.	20,000 sec. ft.	Per H.P. on basis of 75% Efficiency 24 Hour Power 12,000 sec. ft.	20,000 sec. ft.	Per H.P. on basis of Installation 12,000 sec. ft.	20,000 sec. ft	Per K.W. Hour 100% Load Factor 12,000 sec. ft.	20,000 sec. ft.	Per K.W. Hour 50% Load Factor 12,000 sec. ft.	20,000 sec. ft.
1	2	3	4	5	6	7	8	9	10	11
	$	$	$	$	$	$	cents	cents	cents	cents
Pine Falls..............	303,000	447,000	8.00	7.08	5.05	4.47	0.122	0.108	0.244	0.216
*Du Bonnet Falls......	*433,000	635,000	*7.56	6.65	*5.04	4.54	*0.116	0.102	*0.232	0.204
McArthur Falls..................	199,000	272,000	10.82	8.86	7.24	6.40	0.166	0.136	0.332	0.272
†Lower Seven Sisters Falls............		328,000		8.65		5.47		0.132		0.264
†Upper Seven Sisters Falls..........		268,000		9.05		5.58		0.138		0.276
Upper Pinawa..................	128,000	128,000	10.40	10.40	7.11	7.11	0.159	0.159	0.318	0.318
Slave Falls....	228,000	338,000	8.58	7.62	5.70	5.21	0.131	0.117	0.262	0.234
Total..............................	1,291,000	2,416,000								
Mean (based on power output).......			8.47	7.71	5.48	4.21	0.130	0.118	0.260	0.236

*Proportional Annual Cost of development of 12 000 second feet at 56 foot head.

†Upper and Lower Seven Sisters Sites are not feasible of development until the river flow is more systematically regulated.

horse-power on this basis is $7.08, or 0.216 cent per kilowatt hour on a 50% load factor. The average load carried by the Pine Falls plant could, under a regulated river flow, be maintained at 63,000 horse-power and readily carry a peak load of 126,000 horse-power. The actual cost per kilowatt hour is therefore probably more truly represented by the figure 0.108 cent than by 0.216 cent.

These remarks apply with equal force to the estimates of the other projects along the river.

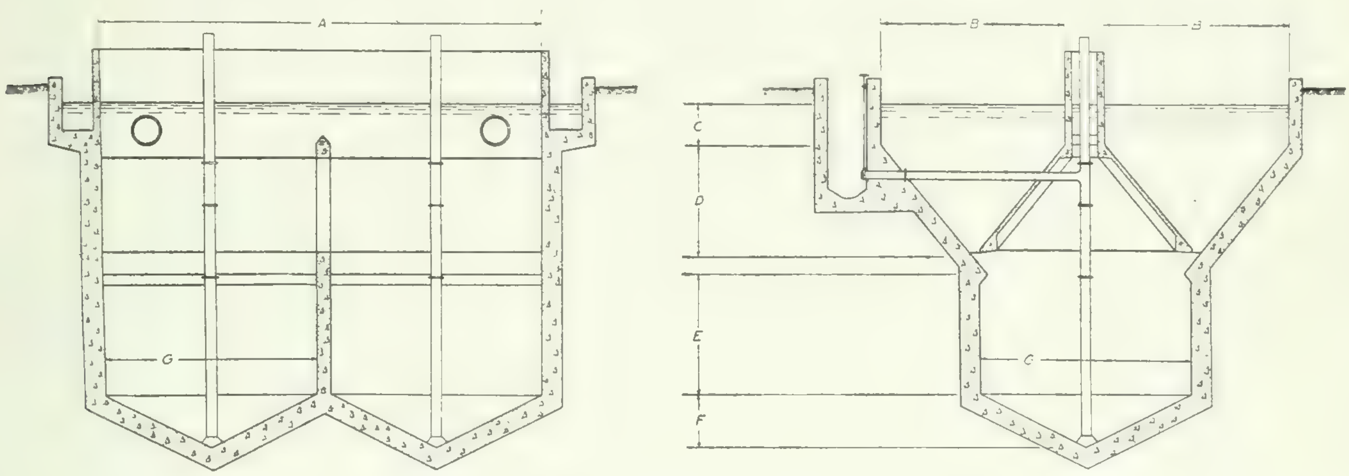
[Part III. (final) will cover the details of a typical concentration as treated in the report.]

WINDSOR DISTRICT SEWAGE DISPOSAL.*

FORD CITY, Walkerville, Windsor and Sandwich, Ontario, are municipalities lying adjacent to one another in the order named and form one large community, which extends for five miles along the Detroit River, directly opposite Detroit, Mich. There are two ferry lines, one in Windsor and one in Walkerville, which make regular trips to Detroit during nearly 18 hours of the day. Passenger and freight connection with the east and west is provided by the Michigan Central, Grand Trunk, and Pere Marquette Railroads. Because of their close contact with one another these municipalities have common interests, regardless of the formal political divisions that exist, and while many of their activities may well be administered by the individual governments without conflict, their drainage problems can be more readily solved by united rather than individual effort. Hence this group of municipalities have been treated collectively as one large community.

There is no sanitary system in Ford City and no complete storm-water system, though there are a few drains which have been provided by the covering over of old ditches. Sanitary sewers are needed and very much desired by the citizens. The municipal authorities, in fact, had a plan prepared in 1914, which was disapproved by the Ontario Board of Health on sanitary grounds, because it called for discharge into the Detroit River above the Walkerville and Windsor waterworks intakes. The main existing sewers of Walkerville, Windsor and Sandwich are all combined sewers and follow streets perpendicular to the course of the Detroit River. They discharge at levels approximately corresponding to normal river stages. There are none that discharge above the Walkerville waterworks intake, but the three which discharge in Walkerville are all above the Windsor intake.

The total population was approximately 12,000 in 1890, 15,000 in 1900, 22,600 in 1910, and 33,000 in 1915. It is evident that the district as a whole has been a rapidly growing one during recent years, Ford City having been stimulated by the automobile industry, Walkerville by automobile and distilling interests, and Windsor and Sandwich by a general increase in industrial development of their own, combined with that of Detroit. Owing to the large territory now covered by Detroit, there are at the present time an increasing number of people who find it convenient to live in Windsor, though they work in Detroit. Furthermore, the excellent traffic facilities, combined with the industrial spirit manifestly present on both sides of the river, should stimulate manufacturing developments so that it is extremely probable that future growth will be rapid also. All things considered, it seems probable that the district will have a population of 100,000 or more within 30 or 35 years.



Typical Sections of Imhoff Sedimentation Tank.
Amherstburg: A = 33, B = 14, C = 4, D = 8.4, E = 9, F = 4, G = 16.
Sarnia: A = 67, B = 14, C = 2.25, D = 8.4, E = 6.5, F = 4, G = 16.

The water records indicate that there is at present a daily per capita water consumption of over 200 U.S. gallons, which no doubt includes considerable waste of various kinds. It does not seem reasonable that this district, when it becomes larger, so that more careful supervision is exercised over water mains and plumbing, will use as much water per capita as the Detroit district with its greater predominance of manufacturing. An assumed future consumption of 180 U.S. gallons per capita per day has therefore been used in this study, this quantity being taken to include the water used for both domestic and industrial purposes, and as contributing 144 U.S. gallons of sewage per capita per day. In addition, a ground-water allowance of 1,000 gallons per acre per day has been used in calculating the size of interceptors.

The territory in and around this district is, in general, possessed of easy slopes, with the river front section of Windsor forming a hump between two lower lying sections, one to the east in Ford City and the other to the west in Sandwich. These sections present the most favor-

*Notes abstracted from report of H. C. McRae, District Engineer, made to Prof. Phelps, Consulting Engineer to the International Joint Commission.

able locations for treatment plants, and have both been considered. The Ford City section was abandoned, however, because of its being located above the existing waterworks intakes. The low land along the river front in Sandwich is ample in extent, and considerable latitude may be exercised in locating a treatment plant in this section. The site selected was chosen, after careful study, as being the most economical from the standpoint of interceptor cost, which is apparently the controlling factor. There are sites otherwise suitable farther down the river, but their use would necessitate a considerably longer interceptor line.

An interceptor has been designed to collect all the sewage of the district upon the basis of 20 persons per acre for 400 acres in Ford City and 30 persons per acre in most of Windsor, Walkerville and Sandwich. Pumping stations assist in decreasing the lift of the entire quantity of sewage when delivered at the treatment works. This interceptor will be large enough to take all the sewage of the district for many years. At some future time other high-level interceptors will be required. The course of future development of Ford City is so uncertain, and the field data so incomplete, that it is difficult to predict at all accurately what requirements the future may bring forth. It is possible that there may be a pumping station required at some future time to lift a small amount of sewage into the proposed high-level interceptor. The lift will be low in any case, and the cost relatively unimportant as compared with the cost of the entire project.

The cost of the interceptor, pumping stations and treatment plant, based on the needs of 55,000 population, is estimated at $404,786. Of this, $123,000 is for treatment plant, $15,800 for pumping machinery, $11,900 for pumping buildings, $9,000 for land and $245,086 for interceptor and Ford City collection system. The estimated cost of operation for labor and materials alone is $16,000.

The cost of the same system based on 110,000 population is $829,187, of which $244,000 is for treatment plant, $15,800 for pumping machinery, $11,900 for pumping buildings, $9,000 for land, and $548,487 for interceptors and appurtenances. The estimated annual labor and materials for operation is $25,000.

TRADE INQUIRIES.

The following inquiries relating to Canadian trade have been received by the Department of Trade and Commerce, Ottawa. The names of the firms making these inquiries, with their addresses, can be obtained only by those especially interested in the respective commodities upon application to: The Inquiries Branch, the Department of Trade and Commerce, Ottawa, or the Secretary of the Canadian Manufacturers' Association, Toronto, or the Secretary of the Board of Trade at London, Toronto, Hamilton, Kingston, Brandon, Halifax, Montreal, St. John, Sherbrooke, Vancouver, Victoria, Winnipeg, Edmonton, Calgary, Saskatoon, Chambre de Commerce de Montreal and Moncton, N.B. Please quote the reference number when requesting addresses:—

448. Iron Steel Merchant Bars, Hoops and Bands, Sheet Steel Rods (Iron and Steel).—Quotations requested c.i.f. Glasgow.

452. Steel Wagon Axles.—A Yorkshire firm desires the addresses of Canadian manufacturers who can supply military wagon steel axles.

453. Bauxite, Asbestos, Silicia, Steatite, Soapstone, French Chalk, Graphite, Plumbago, Carbon, Vegetable Mineral and Animal Charcoal Chrome and other Ores.—A Glasgow firm would be very glad to enter into communication with Canadian exporters of the above.

464. Iron and Steel.—A Birmingham merchant is open to purchase rods and steel billets. Prices c.i.f. Liverpool.

502. Cement.—A firm in Barbados handling cement would like to communicate with firms in Canada in a position to export.

503. Electrical supplies—A well-known firm in Barbados would like to get in touch with Canadian exporters of electrical supplies.

506. Bar iron.—A Barbados engineering firm wishing to import bar and other iron asks to be put in communication with Canadian manufacturers.

508. Hardware—A Demerara commission merchant asks for names of Canadian hardware manufacturers, with a view to securing an agency.

512. Hardware—A commission firm in Demerara, with good foreign connections, desires to represent Canadian manufacturers of hardware.

525. Railway and mining supplies—A Johannesburg firm of engineers is open to take up the representation in South Africa for Canadian manufacturers of mining and railway supplies.

526. Fertilizers—A Durban manufacturers' representative is prepared to take up Canadian fertilizer agency.

530. Agency—A Durban firm of manufacturers' representatives with branch office in Johannesburg is prepared to take up agencies for Canadian manufacturers on commission basis only.

531. Representation—A Johannesburg manufacturers' representative is seeking agencies for Canadian wire nails, barbed and plain wire, handles of all kinds, wheel valves and gun-metal steam fittings.

535. Molybdenum and metals—A gentleman in Paris, France, is anxious to get in touch with producers of molybdenum. He also desires to open connections with a large wholesale house dealing in metals in order to import soft lead, copper, brass, tin, zinc, and antimony, and states that he prefers to be put in touch with a firm of wholesale metal dealers, rather than with producers for technical reasons.

536. Agency—A gentleman who is shortly taking up residence in England desires to get in touch with Canadian firms who require a representative to handle their goods on a commission basis.

574. Hardware.—The proprietors of one of the largest hardware distributing establishments in India desire to receive price lists and catalogues from Canadian shippers of the following articles with a view to opening up trade relations when conditions become normal: Galvanized iron pipe, etc. A catalogue showing the type and price of British and American goods now imported by this firm may be inspected at the Commercial Intelligence Branch, Department of Trade and Commerce, Ottawa.

584. Bolts, Nuts, Screws, etc.—A Glasgow house formerly doing a large importing business in Germany wishes to obtain the representation of Canadian exporters of the above. Best bank references.

585. Chemical Sheet Lead and Malleable Iron Plugs.—A Glasgow firm, hitherto supplied from Germany and the United States, will be pleased to purchase in Canada if price and quality are right. Particulars of specifications will be supplied on application to the firm making the inquiry.

586. Electrical Dynomas, Electrical Switch Gear, Electrical Cable, etc.—A Glasgow firm desires quotations from Canadian manufacturers of the above articles.

598. Representation in New Zealand.—A New Zealander who is at present in New York desires to represent in New Zealand Canadian firms interested in the following lines: Hardware, electrical goods, etc. He will leave for England shortly, and before going will be glad to call on Canadian houses that desire a representative in New Zealand.

599. Builders' Supplies.—An important St. John's firm dealing in builders' supplies asks to be placed immediately in communication with Canadian manufacturers of asbestos shingles.

600. Roofing Felts.—A Newfoundland firm asks for the names of Canadian manufacturers of asbestos roofing and the ordinary one, two and three-ply felts.

614. Wire rods.—A Bradford firm, which has used about 700 tons of wire rods per annum, for overseas since the war began, wishes quotations from Canadian shippers on wire rods and thick sizes of wire.

616. Mild steel plates.—An inquiry is made by a firm in Rotterdam, Holland, for the addresses of Canadian manufacturers of mild steel plates suitable for the manufacture of expanded metal. Full specification of requirements is obtainable on application to the Commercial Intelligence Branch, Department of Trade and Commerce, Ottawa.

WASTE.

By R. O. Wynne-Roberts, Mem.Can.Soc.C.E.

THERE are few subjects which occupy such a prominent position in the discussions relative to our Imperial economy as waste, and there will be no problem that will demand such concentrated attention in the immediate future. Commissions have been appointed by different governments to investigate this matter in connection with the natural resources, commerce, etc. Waste does not necessarily mean the wanton abandonment or destruction of things which can be put to any other use by changing their character. It includes inefficient production, inadequate foresight, lost motion in machinery or operation, redundant labor, etc. Waste is not confined to any particular profession, craft or business; it obtains, in a more or less degree, in almost every sphere of activity, and therefore cannot be attributed, specifically or entirely, to any special reason for it is the outcome of our national methods. Waste, however, has in the past occupied the attention and energy of men, for cities have been built on the profits derived from utilized waste, decaying industries have been revived by the recovery of products from what was previously dumped as waste. Waste gases have been converted into power on a huge scale. But there remains an immense field for further development along these lines. Engineers are probably more concerned in this problem, inasmuch as they, in the aggregate, handle more materials, control more work and spend more money than others, and to them the public must look for the practical application of discoveries by chemists, metallurgists, etc. The subject will be considered from the engineer's viewpoint.

Power is an important factor in connection with most undertakings. Where power cannot be derived from water then it is necessary to obtain it by other means, and, if possible, on the co-operation principle. Ontario is, in a large measure, enjoying the benefits of cheap power which is generated and distributed under a comprehensive communism. With adequate conservation and utilization of the available water power of the province, it is possible for the towns and cities collectively to accomplish that which would be impossible for them to do individually, and further, the cost of the energy is much less by this communistic plan than it would otherwise be. In other words, waste has been reduced. Moreover, waste has also been minimized by "the construction of storage reservoirs scientifically located and operated," for this "is the most effective and only practical method of controlling flood waters in winter and increasing the flow of the stream during the summer droughts" (Walter McCulloch). Although water power is an attractive proposition, there are some conditions and features which render such schemes unremunerative with the result that, although the United States have at command an available energy of 36 million horsepower, possibly five-sixths of it now runs to waste. The water power available in Canada is estimated at about 25,000,000 horse-power but only 2,000,000 of it is now harnessed. There is, therefore, ample scope for development in this direction.

Take another line of thought. Dr. Frank D. Adams stated in an article published in *The Canadian Engineer* of February 18th, 1915, that "less than 1 per cent. of the coal resources of the Dominion are situated in Nova Scotia and New Brunswick, while 87 per cent. lie in Alberta," and that as much coal is wasted as is extracted owing to the methods adopted and that "this waste amounts to very many tens of millions of tons." Furthermore, the Commission of Conservation stated that "Canada's dependance on the United States for its supply of anthracite coal is a point strikingly indicated in the report issued by them on the 'Conservation of Coal in Canada.' Practically all of the most populous portion of Canada lying between Montreal, Que., and Moose Jaw, Sask., relies solely on the United States for its supply of anthracite coal."

It is clear "that Canada should carefully husband her coal resources and, so far as possible, check all wasteful methods of mining and handling coal. With this end in view, the report suggests greatly needed changes in the form of coal-mine leases, the provisions of which should be carefully enforced by a competent engineering authority. This would go far towards preventing the careless practices followed at present in many coal mines. In addition to this, it is urged that the government should carry on investigations with a view to determining the suitability of slack and low-grade coals for use in gas producers for generating power, and their adaptability for the manufacture of briquettes for domestic use. By utilizing these inferior products in this way, not only would there be less waste, but the value of the public coal lands would be considerably increased."

The lignite coal fields of the West are mined to a very insignificant extent. There are about 20,000 million tons of lignite lying in the prairie provinces which are not wasted but are not adequately utilized. This coal is most suitable for gas producers and some day huge central power plants will be located at the mine mouths to generate electrical energy for transmission to many parts of the provinces. Meanwhile, fuel is transported from the United States and from distant west Canadian coal mines at considerable cost, constituting another form of waste. Whilst many Canadian works have relatively efficient power plants, the majority cannot be placed in this category. Consequently central plants would be productive of great savings. It is worthy to note that there is a movement in Britain for great conservation of waste heat. The following is a cutting from the Engineering Supplement of the London Times for April 28th, 1916:

"The growing attention that is being paid to methods of utilizing the large quantity of surplus heat which is a by-product of our manufactures is a hopeful sign. The public discussion on the question which has just taken place at Sheffield was remarkable for the fact that it attracted the attendance of representatives of the iron and steel trades and scientific men, as well as those associated with gas, electricity, and colliery undertakings. The suggestion that there should be established a government department to control the supply of power and electric current on national lines is a somewhat drastic one, and a very strong case would have to be made out before it would be likely to find acceptance. But the proposal to harness all the waste energy of the South Yorkshire coal field and employ it in the form of gas or electricity in the iron and steel trades of the district is certainly attractive, the broad lines of the scheme being that the individual manufacturer in the Sheffield district should cease to provide his own power plant in favor of drawing supplies from a huge central station which would generate current from the waste energy available in the local coal field. It is suggested that if this plant met with general acceptance it would be possible to supply manufacturers over a wide area in the West Riding with current for power purposes at the low rate of .25d. per unit. There are many directions in which economies can be effected in manufacturing operations, and the provision of a source of cheap power supply would be least among them."

Whilst the idea of governmental control of power is new, the principle is old. For example, there is a large central power scheme which has been in very successful operation in the vicinity of Newcastle-on-Tyne for many years. The capital invested amounts to a large figure, in the neighborhood of $50,000,000. Another instance is the large central power plant for the Rand, in South Africa. In both instances waste has been eliminated to a very great extent. The waste of fuel at individual power plants will in the aggregate amount to a large figure. It is highly desirable that the engineers in charge should be given every inducement to operate gas-testing instruments so that the gases passing to the chimney stacks should contain the minimum of combustible constituents.

Another cause of waste is the method of producing metallurgical coke. There are nearly 3,000 coke ovens in Canada, but only 730 of them are constructed to save the valuable by-products, such as gas, tar, ammonia, etc. The gas from coke ovens should be available for power and heating, and if used in gas engines there is sufficient surplus gas from every ton of coal to provide 250 horse-power-hours. The quantity of ammonia will suffice to produce about 20 pounds of ammonium sulphate, which is valuable for fertilizing the land. The ammonia may be reduced to concentrated crude ammonia for refrigerating purposes, or utilized for cleansing. These are only a few uses to which the ammoniacal liquid may be applied. The tar is one of the very valuable complex by-products of coal, which can be distilled for several hundred uses. Creosote for preserving wood, constituents for high explosives and dyes are the pressing needs of the hour, but in 2,000 ovens in Canada the tar is not recovered and the Empire has to buy elsewhere. The Minister of Munitions is urging every possible producer of tar in Britain to concentrate on the production and conservation of that commodity for the manufacture of trinitrophenol, commonly known as picric acid, which is required for the manufacture of high explosive shells. While the fact is very unpalatable to us, we must, nevertheless, recognize that the Prussian autocracy managed in a remarkable manner to marshal all the economic forces of the German empire, and many outside of that country, for its use. We know that in ante-bellum days science was applied to almost every German process and business, and that the doctrine of efficiency was persistently advocated on practically every hand, under the direct influence of the government and state authorities, so that waste was at its minimum and production at its maximum, and German power in all lines became international and phenomenal. Any efforts made in this and other countries to emulate them in the conservation of resources, if it had any tendency to interfere with their secret plans, were promptly met by German commercial competition, so keen and effective and methods not always scrupulous and fair, that reduction of waste outside Germany was often made impossible, or nearly so, and thereby highly advantageous to Prussian military ambitions. Those interested in the effect of German policy on the American chemical industries and how American consumers were influenced during the last few years, can with advantage peruse a paper by Mr. H. W. Jordan, read at the Baltimore meeting of the American Institute of Chemical Engineers. German policy and science resulted in their building up huge industries at our expense. They made it unremunerative for others to reduce or convert waste because it manifestly would jeopardize the Prussian military programme. Tar and other by-products of coal distillation became the most important raw materials of the immense German chemical industries. Their coke ovens were almost entirely of the recovery type, so that all by-products were conserved; the public had been educated to use gas, and to keep up the consumption during the war; farmers had been taught to fertilize the land with sulphate of ammonia. Synthetic dyes were sold to the world—at a loss, if it was necessary, to stifle a budding local industry. So that when the time arrived, Prussia had the necessary picric acid, etc., for military use and the equipment to produce them. Meanwhile, the waste of coal and its by-products in North America was stupendous. It requires time, capital and skill to change the methods and plant, and consequently the highly desirable alteration cannot be made in time to be of the greatest service to the Allies, but the lesson should be borne in mind.

The waste of wood in Canada is estimated by Mr. W. B. Campbell, B.Sc., to be from $10 to $15 per year for every man, woman and child in the country. The chemical engineer has here a great scope for his skill and ingenuity.

Water waste in our towns and cities is an important matter. There are no statistics available which will indicate the annual loss incurred in this way. But the magnitude of the waste may be illustrated by a simple calculation. The population of Canada is about 8 million, of which about one-half dwell in the towns and cities. The average daily consumption of water may be placed at 80 gallons per capita—this figure is conservative. It is quite reasonable to assert that 50 gallons should suffice, and therefore there are 30 gallons per head per day which might be saved. The excess quantity is equal to 43,800 million gallons per annum. We may assume that it has to be raised 100 feet, which is a low lift, and that the fuel alone costs only 2 cents per million foot-gallons, which is the lowest published cost in North America, then the excess cost will be about $87,600 per annum. This is a respectable sum to consider, but it is by no means the total cost, for labor, capital charges, maintenance, etc., have yet to be added; and, furthermore, the excess volume of water has to be disposed of as sewage. So that the grand total cost to the ratepayers will be many times the above sum.

Apart from waste in water and its inherent expenditure, there is the other side of the problem. The sources of supply are not always beyond doubt as to their purity. It is essential that every precaution should be taken to safeguard the health of the consumers. A large daily consumption of water necessarily entails great systems of water treatment. It is unnecessary to postulate that an abundant supply of pure water is a modern necessity and costs less than do violent outbreaks of typhoid and other water-borne diseases. There have been sufficient instances to prove this statement. Yet, the fact does not seem to be impressed home, for the papers continue to announce waste of life due to this cause. Preventable waste of life is deplorable. Dr. E. F. Campbell, of the Ohio State Board of Health, stated that "carefully prepared tables show tuberculosis as 75 per cent. preventable, typhoid fever as 85 per cent. preventable, diphtheria as 70 per cent. preventable." If some of the older nations can afford to sacrifice life because of unsanitary conditions, new nations cannot afford to do so, for their greatest asset is vigorous life. But older nations have mostly learnt by experience that to conserve life by supplying pure water and providing efficient sanitation is an excellent investment. The marvellous health records at the front prove that this fact has been firmly and permanently established. It is stated that a person is worth to the community the difference between his or her earning power and the individual's cost of maintenance, which sum represents 6 per cent. of the total value. Whether this statement has

a reasonable basis is not under discussion, but assuming its correctness, then a person earning $1,200 per annum and spending $900 for maintenance, is worth $\frac{(1,200 - 900) \times 100}{6} = \$5,000$. The waste of life due to typhoid, therefore, represents a great loss to any municipality. Such waste cannot be tolerated where the public appreciate the economy of pure water. The other losses due to waste of life are not referred to because they are not pertinent to the question under discussion.

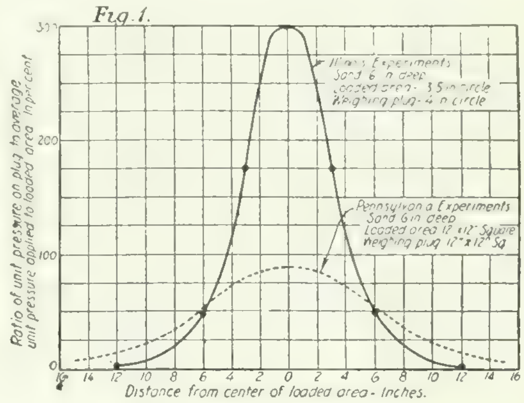
Mr. Thomas Adams has frequently referred in his addresses on town planning and allied subjects, to the question of street widths. This question has engaged the attention of engineers in many parts, and it has been discussed at international road congresses, but not always from the same viewpoint as that taken by Mr. Adams. He points out that the number of streets in any city that constitute the main arteries for traffic are relatively few, and yet, as present, the widths and construction are virtually the same in busy commercial quarters and in purely residential districts. Where the traffic is great, the street should be wide, but where the traffic is small it is unnecessary to provide similar traffic accommodation, at any rate until it is actually required. The lines of communication are fixed by various conditions, and it is often impossible and always exceedingly expensive, to change them, or create new ones, after the area has been built upon. Moreover, with easy and rapid means of transportation the people are migrating to the rural parts of the towns and cities. They desire to enjoy the quietness and beauties of nature after their daily toil in the noisy city. Many, however, cannot afford to travel far away from the centre of employment and have to dwell in the parts which are as desirable as possible. It, therefore, is not essential to urbanize all parts by constructing streets of an expensive character. The expenditure of money beyond what is actually required to accommodate the locality is waste, and renders the cost of living higher than it should be. It also spoils the desirability of the locality as a purely residential district.

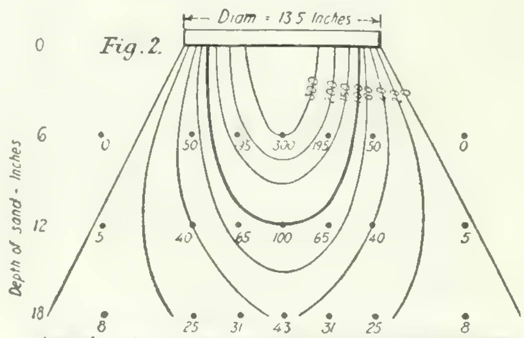
Municipal engineers in particular are concerned in the problem of how to minimize the waste by fire. The Monetary Times for January 7th, 1916, published statistics showing the losses incurred during the last five years. The average annual total for Canada was $21,740,000, but, fortunately, in 1915 it was less—$13,670,000. The average number of houses burnt per year was 692; stores, 317; factories, 102; business sections and blocks, 70; warehouses, 47. The average loss of lives was 221 per annum. It is worth noting that in 1915, 55 fires were caused by electrical defects, 51 by defective and overheated stoves and furnaces, 62 by defective and overheated pipes, chimneys, etc. These and other causes suggest great preventable waste, that adequate prevention would have cost but a mere fraction of the losses incurred. No one wants to live in a district where certain diseases are endemic, neither do manufacturers and tradesmen want to build factories, stores and houses where fires are frequent. So that building by-laws and their administration have a direct influence on the ultimate prosperity of a town. Fire insurance rates are based on experience and are more or less proportional to the hazards involved.

Waste might be discussed in its relation to many other matters but for the present the foregoing will doubtless suffice to draw attention to the urgent need of the time. Canada has a golden opportunity to develop the waste or by-products of various industries, and to adopt measures to prevent waste of every form.

THE DISTRIBUTION OF PRESSURE BY GRANULAR MATERIALS.

VERY little is definitely known as to the way in which the pressure of a wheel on road metal or a sleeper on its ballast is transmitted to the underlying foundation. It is generally held that the intensity of the pressure due to an isolated load diminishes as the depth increases, and the assumption is sometimes made that at any depth the pressure is uniform, and confined to the base of a cone having the load at its apex and with its surface inclined at an angle of 45 deg. to the line of the load. Some definite information on this head is provided by some experiments recently carried out in the engineering laboratories of the University of Illinois, a description of which is contributed by Professor M. E. Enger to a recent issue of the Railway Review. The experiments were made by applying a local load to a bed of sand supported on a concrete floor. An opening in the floor 4⅛ ins. in diameter was closed by a plug 4 ins. in





Lines of equal vertical unit pressure - expressed as the percent which the average vertical unit-pressure on the 4 in plug is of the average unit-pressure applied to loaded area.
(4664)

diameter, which rested by a knife-edge on a lever, the outer end of which was borne by the platform of a weighing-machine. The load was applied to the upper surface of the sand by means of a circular plate, the diameter of which ranged in different experiments from 9 ins. up to 21 ins. In the first instance the load was applied centrally over the plug already mentioned, and the weight borne by the latter was recorded. The pressure-plate was then shifted a little to one side, and the observation repeated. By proceeding in this way sufficient data were obtained to make it possible to plot a curve showing how the pressure on the sand varied with the distance from the line of load. The sand was thoroughly compacted before taking a reading. If, for example, it was intended to determine the pressure distribution at a depth of 12 ins., the plate was started on a layer about 15 ins. deep and forced down to 12-in. depth. The load was then released and reapplied

several times in succession, readings of the pressure borne by the plug being taken during each of these reapplications of the load. The interesting fact was established that at shallow depths the intensity of the load on the plug might be very considerably greater than the average pressure applied at the surface of the sand. Thus in one series of experiments in which the pressures were measured by a diaphragm gauge 6 ins. in diameter, instead of by means of the 4-in. plug aforementioned, the following figures were observed:

	Depth below Surface.			Diameter of Load-Plate.
	6 in.	12 in.	18 in.	
	p.c.	p.c.	p.c.	in.
Average pressure on 6-in. gauge	72	43	19	9.0
" " " "	100	60	40	13.5
" " " "	—	105	62	21.0

The figures given show the average pressure per square inch on the 6-in. gauge, as compared with the average pressure per square inch on the load-plate when this is concentric with the gauge. Obviously, since the pressures given are averages, the maximum pressure along the centre line must be considerably higher. The diaphragm gauge was found to be unsuitable for "out-of-centre" observations; but the results obtained with the wooden plug made it possible to plot curves showing the distribution of pressure. These were found to have the character illustrated in Fig. 1. The shape of the curve recalls that of the "error function," and is, moreover, very similar to the curves of pressure distribution that are found when a jet of water strikes a flat plate normally. Curves of this kind are reproduced in Professor Unwin's article on "Hydraulics" (Encyclopædia Britannica, 11th edition). Professor Enger has also plotted the lines of equal pressure which we reproduce in Fig. 2. In further experiments the motion of the sand was observed when a load was applied to a mass one side of which was retained by a sheet of plate glass. By applying the pressure slowly, the motion of the sand was recorded, as short streaks, in a photograph taken simultaneously. The stream lines thus found should be presumably perpendicular to the corresponding lines of equal pressure. This presumption cannot, however, be tested from Professor Enger's photographs, since the size of the pressure block used in determining the lines of pressure was not the same as that with which the lines of flow were recorded. One result which appears to be fairly deducible from the experiments is that the distributing power of sand is not as great as would be anticipated from the 45 deg. rule referred to at the beginning of this article.

The House bill at Washington, D.C., providing for the reclamation by the Government of 2,300,000 acres of Oregon land granted the Oregon and California Railroad, has been passed by the Senate. The lands, valued at about $30,000,000, are alleged to have been forfeited by violations of the terms of the grant, which required their sale to settlers at $2.50 an acre.

According to the annual report of the Ontario Workmen's Compensation Board there were 7,600 accidents which came under its jurisdiction during the year. Arranged according to counties, York, Wentworth, Algoma and Sudbury had the largest number of accidents in the order named. The reason for this is evident, all four of them containing large industries, thus making the hazard greater. The report also shows that 27.61 per cent. of accidents were due to machinery and its parts, 2.74 per cent. to hoisting apparatus, 8.20 per cent. to dangerous substances, 34.04 per cent. to falling, rolling and flying objects, 6.08 per cent. to the use of tools, 1.03 per cent. to runaways and animals, 3.55 per cent. to moving vehicles, 14.47 per cent. to personal falls, and 2.29 per cent. to all other causes.

ROAD MAINTENANCE, MATERIALS AND METHODS.*

By William H. Connell,
Chief, Bureau of Highways and Street Cleaning, Philadelphia.

A GOOD organization is essential, particularly in so far as maintenance is concerned, as it is practically impossible to continuously and systematically maintain pavements and roads in first-class condition in an economical manner, without a good working organization built up along the lines best adapted to cope with the conditions involved in this important branch of work coming under the jurisdiction of a highway department. By this it is not intended to give the impression that the maintenance organization should be separated from the construction, as separate organizations are apt to result in an overlapping of jurisdiction and a tendency to shift responsibility, and open up a field for unlimited excuses, as to whether the construction or maintenance division is responsible for any unsatisfactory conditions that may arise relative to the pavements. Furthermore, it is obvious that the logical organization to maintain the pavements is the one that saw them laid and is familiar with every detail of the construction, as very often a knowledge of apparently trivial conditions in connection with the construction bears an important part in the future maintenance.

It is the intimate knowledge of the details of both construction and maintenance, not considered separately but in their relation to one another, that is so desirable as a future guide in highway engineering; consequently the combination of the two organizations in one will accomplish far better results than they would working more or less independently of one another, each with a limited responsibility. Highway engineering may be considered a specialty, but further specializing in construction and maintenance is not logical, as the two are dove-tailed and cannot be considered separately. Every engineer engaged in highway work appreciates the fact that there is no such thing as a permanent pavement for either city streets or country roads, consequently, in addition to the cost of construction, the maintenance repair charges during its life must be included in the final cost, and is a most important factor in the selection of a pavement.

The main and most perplexing problem of a highway department, no matter whether the department be a state, municipal, county or town department, is, or eventually will be, that of maintenance. If a large percentage of the roads or pavements are constructed, which is usually the case, then the maintenance predominates, and in fact it is only in localities where there are practically no roads or pavements, that the maintenance is subordinated to the construction.

The activities coming under the jurisdiction of the municipal and state highway departments are not similar in every respect, but the principal functions do not differ sufficiently to affect the problem in the main.

A large municipal department embracing street cleaning, collection and disposal of ashes, garbage and rubbish, and snow removal, together with the general problems, such as construction and maintenance of pavements, etc., embraces a greater variety of work than does a state department, but principally of a nature that is essentially maintenance work. Likewise in a large state department with an active organization controlling a large area of

*Paper read before the 3rd Canadian and International Good Roads Congress, March, 1916.

improved highways, the maintenance problem is more involved and complicated than in a county or state department with a less mileage of pavements or roads under its care, so that the perplexity of the problem increases not only with the number and variety of activities, but with the area of the territory and the mileage of roads and pavements coming under the jurisdiction of the department. It is, of course, a much simpler matter to cope with this problem where the work involved is such that it can be controlled from a central office, without delegating the responsibility to divisions and sub-divisions of the organization. This is especially true in maintenance work, as there is always a tendency among engineers to be lax in attention to details of an apparently simple and routine nature. They are apt to overlook the fact that it is no trick to construct a pavement, as in supervising this work they are simply following more or less standard, and well-defined principles, where, in maintenance work, there is no set specification to follow, the success depending upon attention, to a certain degree, to daily routine and principally to petty details that present themselves in the actual physical work, and in this there is an unlimited field for initiative. Personal experience in observations of the wear and peculiarities of the different types of pavements and road surfaces is invaluable as a guide in research work, as there is not a pavement to-day that cannot and should not be improved upon. The difficulty of impressing upon the supervising force the importance of this close personal attention to detail in connection with the care of the pavements is probably the most important single factor in the operation of a large highway department, and must be reckoned with, and especially in these times when the public are becoming more and more exacting and virtually demanding that the roads and pavements be kept continuously in good repair. This should be obvious to all engineers in charge of highway organizations.

For convenience the different branches of maintenance work will be grouped under the following classifications:

1.—Routine maintenance.
2.—General maintenance.
3.—Emergency maintenance.

Routine maintenance includes such work as the regular street cleaning in municipalities, and the cleaning of country roads and gutters, and any other work of this character that is more or less routine, and should be performed under a definite schedule. The streets in the thickly populated sections of the city should be cleaned every day; in less thickly populated sections, every other day; every third, and so on until we come to the country roads, which should be cleaned once a week, once every two weeks, and some only once a month, depending upon the amount and character of the traffic which largely governs the frequency with which the cleaning should be done. The amount and schedule of work and the force necessary to perform it can be determined upon in advance and carried on in a systematic manner under a regular organization, more or less military.

General maintenance includes repairs to streets and roads, and involves different characters of work, each requiring special knowledge on the part of those engaged in the actual performance of the physical work for which special gangs have to be organized. Stone block, wood block and brick repairs, for example, require skilled laborers who have made a specialty of this work, and are employed under the title of pavers and rammers; while repairs to asphalt and bituminous pavements must be performed by men specially trained in this line of work, in addition to the necessary force engaged at the mixing plants. Macadam road repairs, the care of earth roads, the bituminous surface treatments, also require men specially trained, and while it is desirable to train the gangs for each particular branch of this work, such, for example, as bituminous macadam built by the penetration method, waterbound macadam, bituminous surface treatments, and the care of earth roads, the three classifications, namely:

1.—Block pavement repairs.

2.—Bituminous pavement repairs (mixing method), sheet asphalt, bituminous concrete, etc.

3.—Country roads, macadam, gravel, etc.; bituminous surface treatments, and earth road repairs,

represent the three branches into which the organization is usually divided. Further subdivisions can be handled by those directly in charge of the different classes of work coming under these divisions by training the laborers for the particular character of work to which they are assigned.

This illustrates the difficulty of handling the work coming under the heading of general maintenance, which not only requires separate organizations made up of men specially trained in the different branches of the work, but the character and amount of the work itself is of such an indefinite quantity that it is very hard to control, and, furthermore, can only be performed in seasons of the year when weather conditions are suitable, all of which tends to make it difficult to maintain a good working organization, as is always the case when men are not regularly employed all year round.

The principal element leading to success in this work is the application of the theory that a "stitch in time saves nine." This not only applies to the patching of different characters of pavements, but to bituminous surface treatments, particularly when the treatment only consists of a paint-coat lightly covered with washed gravel or chips, which is only intended to last for a year or two. Very often when a treatment is required on a road, and the performance of the work is postponed for a couple of weeks, the road will deteriorate and require resurfacing, so that it not only necessitates a more or less flexible organization for the actual performance of the work, but a very thorough study of the probable amount of material required, which should be purchased sufficiently in advance to avoid any delay in furnishing the material. This requires in addition to an efficient overhead organization, composed of engineers well versed in the art of carrying on the work, a thoroughly systematized procedure suited to bring about the best results under the conditions to be met.

The third classification, or emergency maintenance, consists of such work as snow removal and taking care of extensive washouts, both of which require an emergency force, as work of this character must be performed at once, and necessitates putting on an indefinite number of men, depending upon the volume of work, usually for only a short period of time. This makes it necessary for the organization to keep in touch with all available sources where men can be employed on short notice.

These are some of the reasons why the maintenance problem is the most difficult one in a highway department. Construction work, in the first place, is usually carried on under contract, and all the cares and troubles relative to the labor situation are up to the contractor. The department requires the contractor to perform a specific piece of work under definite conditions, and is only charged with the inspection, and the responsibility of seeing that it is performed in accordance with the requirements of the specifications. While, in the maintenance work the

burden of the responsibility is up to the officials of the department not only in so far as the character of the work is concerned, but for the control of the organizations engaged in its performance.

The details of the different characters of repair work including the methods and materials used are, of course, very important, but nothing like as important as the length of time that elapses between the origination of the necessity for the repairs and the performance of the work. Repairs should be made as soon as the defects, no matter how slight, present themselves, and not weeks afterward. The secret of success in highway work is continuous and systematic maintenance. The upkeep is the real problem. The highways should be patrolled every week, and oftener if necessary, and all defects reported and repairs made at once.

The general methods employed to maintain a system of highways in good condition are the patrol method and the gang method. The patrol method usually consists in having a man with a team and the repair equipment patrol, and be responsible for making repairs to a certain, definite length of highway. The gang method consists in sufficient gangs being employed, equipped with all the materials to make repairs where ordered; the difference between the two methods being that in the first method the man who makes the repairs also patrols the highways, while the gang method is dependent upon the reporting of defects being made by special patrolmen, who may be inspectors, engineers, etc. There is some difference of opinion as to the better method, but it would seem that the reporting of the necessity for repairs by a special patrol inspector and the making of these repairs by a specially trained gang would be the better method. A detailed description of the methods of making repairs to the various types of roads and pavements would constitute quite a voluminous document. Consequently, it will only be possible to discuss the fundamental principles.

Dirt roads should be well crowned and drained. The shoulders should be kept clear, and the drainage ditches open. Road drags and road scrapers must also be used from time to time in order to keep dirt roads in good condition. An application of about a 20 Baumé gravity road oil once a year will not only lay the dust, but will help to compact the road surface under travel and form a sort of crust.

Gravel and waterbound macadam roads should be well crowned, well drained, and the shoulders and drainage ditches kept clear. The most effective method of maintaining gravel and macadam roads is through the use of bituminous surface treatments. The method and type of treatment used, however, will depend upon whether it is to be used for a gravel or macadam road, and the character of gravel and stone used in the construction of the respective types of roads. On other classes of roads and pavements, such as bituminous pavements by the mixing and penetration methods, cement, concrete brick and stone block pavements, it is also important to keep the roads well drained, the shoulders clear, and the drains and ditches open. The methods of bituminous surface treatments used on the city of Philadelphia suburban and country macadam and dirt roads are as follow:

The suburban and country streets and roads receive bituminous surface treatments of the character best suited to the respective roads, which are selected only after making a study of the type of construction, the traffic and social and local conditions in each instance. Generally speaking, two methods of treatment are used on the roads. For convenience they are divided, first, into bituminous surface treatments, intended to eliminate the dust nuisance and preserve the roads, and secondly a cheaper method of bituminous surface treatment, used simply for the purpose of laying the dust on macadam, cinder and dirt roads, and not intended to preserve the road to any great extent.

The first method of treatment is used only on macadam roads that have been put in good condition, as it is a waste of money to put a high-class bituminous surface treatment on a road that is full of ruts and pot holes, and not properly shaped up. The bituminous materials used in the city of Philadelphia consist of coal tar treatment, hot application, known as Tarvia A, coal tar treatment, cold application, known as Tarvia B, water gas tar treatment, hot application, known as Ugite No. 2, water gas tar treatment, cold application, known as Ugite No. 1, and asphalt cut-back treatments which consist of a mixture of 60 to 65 per cent. of 80 to 100 penetration asphalt, conforming to specifications adopted by the Association for Standardizing Paving Specifications at Pittsburg in 1913, and 35 to 40 per cent. of 53 to 60 commercial naphtha. All of these materials are applied in quantities just sufficient to paint the road and to avoid possibilities of building up a pad. In other words, the purpose is simply to have a film coat of bituminous material on the surface of the road and to re-treat the road as often as is necessary to maintain the film coat, and in this way eliminate the pushing and rolling under traffic, which occurs with bituminous pads.

The method of applying these bituminous materials, when the road is in proper condition to receive such a treatment and the material to be used on the respective roads has been selected, is as follows: The roads are first lightly sprinkled with water and then swept with a horse-drawn broom. They are then swept with hand brooms until the surfaces of the stone are free from dust. This sweeping, however, should not be done in such a manner that the stone dust or binder will be removed from between the stones. The bituminous material is then applied with a pressure distributor at a certain rate per gallon, which varies on different roads, depending upon their condition, and also whether it be a first, second or third treatment. The bituminous material is then allowed to remain on the road for about twelve hours, or over night, after which fine washed gravel—

Passing ½-inch screen	100 per cent.
Passing No. 4 screen	50 to 60 per cent.
Passing No. 6 screen	20 to 30 per cent.
Passing No. 10 screen, not over	10 per cent.

is spread over the road at the rate of 13 to 18 pounds to the square yard, depending upon the amount of bituminous material applied. In some cases clean trap rock chips passing a ⅝-inch ring and maintained on a ⅛-inch ring are used.

The theory of using fine washed gravel in place of stone chips is two-fold; first, to provide a covering that will not grind up and pulverize before the bituminous material has set up, and thus incorporate with it and build up a pad, such as is the case with the stone chips as they pulverize very quickly under any appreciable amount of traffic; second, it only contains 10 per cent. of the fine sand and the pebbles constituting the rest of the material are so hard that they do not grind up and pulverize for from three weeks to two months, depending upon the traffic. The process of pulverizing is so slow that the fine material is washed off the road after each rain, thus doing away with the necessity of sweeping the road to eliminate the dust, which is necessary where stone chips are used.

These treatments last for a year and have proved to be not only the most economical method of preserving roads of this character, but the cost is less than the cost of sprinkling with water, provided the roads are sprinkled three times a day and this, by the way, is not sufficient to lay the dust, and, of course, it must also be understood that the sprinkling with water will not preserve the roads under automobile traffic.

The second class of treatment generally used consists of asphaltic road oil from 18 deg. to 23 deg. Baumé gravity. This material is applied to all of the macadam roads that are not in fit condition for the first-class bituminous surface treatment, and to all dirt roads, and is applied at the rate of 2/10 to ¼ gallon to the square yard. On some roads, depending upon the amount of traffic and whether or not the road is shaded, it is necessary to treat the road in May and treat it again in September. Such roads, however, are the exception. In most cases this method of treatment will last for one season. The roads as a rule are not swept before the application, nor is any covering put over this bituminous material, as it is applied in such small quantities that there is scarcely any necessity for covering. The purpose in putting on this small quantity is to insure its disappearing from the road before the winter sets in, in order to avoid the mushy condition that prevails when there is too much oil on the road in this season of the year.

The paint coat method of tar bituminous surface treatments on first-class macadam roads has been a success for seven or eight years in this country, and it has also been used to a very great extent for a number of years in England.

The asphalt cut-back paint coat treatments are somewhat new, and have been largely developed in Philadelphia during the last four years. The successful results in Philadelphia have led to its use in other localities in the east this year, notably by the Highway department of the State of Pennsylvania, where a large mileage of roads have been treated using this method.

The asphalt cut-back bituminous surface treatment was evolved through research work carried on with a view to finding some way to utilize an asphalt in the paint-coat method of treatment which had been so successful with the tars. In order to do this, it was necessary to use a comparatively stiff asphalt so that it would set up quickly on the road. This necessitated cutting back an asphalt of about 100 per cent. penetration with from 35 to 40 per cent. of naphtha. The purpose of the naphtha is to make the material of such a consistency that it can be applied to the road when it is moderately warm. In other words, the naphtha simply acts as a carrying agent, and after it has done its work, it evaporates and leaves the paint coat of asphalt on the road.

This material has proved to be a success under a four-year test, re-treating, of course, every year or two, or as often as is necessary, as is also the case with the tars.

The methods of bituminous treatments described, however, are not applicable to all conditions. The roads treated must be built of comparatively hard stone, and the traffic conditions must be taken into consideration.

The method of bituminous surface treatment described for macadam roads built of hard stone and in good condition can also be used on gravel roads constructed of materials similar to what is commonly called Poughkeepsie gravel, which consists of large and small sized stones with fine gravel for a binder. Where the gravel is composed of any appreciable amount of clay, this method of treatment would not give very satisfactory results. The dust layer referred to, however, would benefit such roads to a considerable extent. In discussing these bituminous surface treatments it will be noted that great stress has been laid on a paint coat or film coat to be renewed each year or so, or as often as necessary. The object of this paint coat or film coat is to avoid the formation of a pad, but where the road is built of soft stone that would naturally be affected more by traffic than would the hard stone, this paint coat or film coat would not be satisfactory. In such cases, it would be necessary to use a larger amount of bituminous material and build up a ⅜ to ½ inch pad. It is practically impossible to give any general description for bituminous surface treatment work that will apply to all conditions, but there is no road that cannot be benefited by the application of bituminous surface treatments. It is, however, very important that all the details of the cleaning, etc., previously described, should be given very careful attention, and the roads should be re-treated before they have gone into a condition of bad repair. After these re-treatments have been applied, that does not mean that they will not require any attention until the following year. Some roads, of course, will not require any attention until the time for the re-treatment, but a great many of the roads where the traffic is heavy will require patching all through the winter. The methods used in patching these bituminous surface treated roads in Philadelphia are as follow: Where the surface treatment has worn off in spots and there is likelihood of a pot-hole forming, the road is painted with tar used for cold treatments or asphalt cut-back, depending upon the character of material the road was originally treated with, and chips or gravel spread over the area of the surface that has been painted. Where pot holes have formed, a mixture of ¾-inch stones and a heavy tar somewhat similar to Tarvia A or an asphalt of about 100 penetration is placed in the hole and tamped, and dry gravel or chips spread over the surface. This can be done by heating the tar or asphalt on the road and mixing it with the stone, but a more effective and better way to handle this kind of patching is to make up a mixture of the tar and stone, and asphalt and stone and place it at different locations along the line of the system of highways. By the use of a suitable mixture of asphalt or tar cut back with naphtha, it is possible to prepare large quantities of patching material which will not set up so that it cannot be rehandled and used for repair work during the winter, without the necessity of reheating. This is known as the cold mixing method of patching bituminous macadam and bituminous surface treated roads. Such materials as Amiesite and Bicomac are also adapted for winter patching, and have given very satisfactory results. The main point that should be, and has been, brought out in connection with repairs to roads and pavements of all descriptions is to make the repairs promptly when there is the slightest indication of the necessity for repairs, and thus avoid pot holes in the country roads and necessity for making extensive repairs to roads and pavements of all descriptions.

Now that you are building a large mileage of highways in Canada, it will not be long before your maintenance problem predominates as it will be looming up larger each year, and you have a splendid opportunity to avail yourself of the experience gained by the failures in other localities where there has been a great deal of highway construction. In conclusion, it will not be an unfair statement to say that the failures in highway construction have been very much exaggerated. The trouble has been principally, however, the failure to maintain the roads and pavements after their having been constructed.

SURGES IN AN OPEN CANAL.*

By R. D. Johnson.

SYNOPSIS.

This paper points out a rational theory upon which to base research into the rise of water in a canal, following an interruption of flow, due, for example, to a shut-down of a water-power plant. It calls attention to the analogy between this surge and the phenomenon known as the "hydraulic jump."

THIS interesting subject always comes up in connection with the problem of how high to build forebay walls to avoid overflow in case the motion of the water in a canal is suddenly arrested by a short circuit. Trouble from this source seems to be very infrequent, and yet a sound theory for the computation of the height of the surge wave has never come to the writer's attention. The reason that wash-overs have not been more common seems to be due to the fact that, for ordinary velocities, the surge is comparatively small, and a good fair guess usually proves a sufficient safeguard; nevertheless, it may be interesting to set forth what appears to be the beginning of a sound theory, applicable to such cases.

Neglecting friction, in a smooth, rectangular flume, the sudden dropping of a gate would seem to cause a backward rolling wave which consumes a part of the energy of the oncoming water in eddy losses, and accounts for the remainder in an increased depth behind the wave, the water standing still and level between the wave and the gate. On this theory, an equation from which the depth of the water may be determined is expressible through recourse to the well-known law that force is equal to the rate of change of momentum; for, if the depth of the water in motion is d and that of the water at rest is D, the total free force acting (for unit weight of fluid and unit width of flume) is $\frac{D^2 - d^2}{2}$ and, in the time, t, during which Qt cubic feet of water passes, with a velocity, v, and also Qt cubic feet of water is projected backward over the top, so to speak, of the oncoming stream, the quantity of water brought to rest is Dt multiplied by the velocity of propagation of the wave, or,

$$Dtv_3 = Dt \times \frac{Q}{D - d},$$

the change of momentum is

$$\frac{DQtv}{g\,(D - d)},$$

and the rate of change of momentum is

$$\frac{DQv}{g\,(D - d)},$$

whence,

$$\frac{D^2 - d^2}{2} = \frac{D\,d\,v^2}{(D - d)\,g} \quad \ldots\ldots\ldots\ldots (1)$$

from which D may easily be determined by trial.

It may be observed that as velocity is only relative, the height of the "jump" which takes place in this case should agree exactly with the formula for the "hydraulic jump," if the proper corrections are made in the velocities relative to the earth, in such manner that the wave would "stand still" in the ordinary acceptation of the term. In other words, no error in theory is introduced if, while the above phenomenon is in progress, the whole flume is regarded as moving bodily, with a velocity, relative to the earth, equal and opposite to that of the wave propagation; and such modifications ought to, and do, reveal the formula for the ordinary "hydraulic jump."

In this case, the absolute velocity of the water approaching the wave would be

$$v + \frac{Q}{D - d} = v_2$$

and the absolute velocity of the deeper water, at depth D, would be

$$\frac{Q}{D - d} = v_1, \text{ and } v_2 - v_1 = v, \text{ as before.}$$

The new quantity, $Q' = D\,v_1 = \frac{Q\,D}{D - d}$.

The formula for the hydraulic jump is,

$$\frac{D^2 - d^2}{2} = \frac{Q'}{g}\,(v_2 - v_1)$$

and as D and d are unchanged, we may substitute for the foregoing values of v_2, v_1, and Q', their equivalents in terms of Q and v, as follows:

$$\frac{D^2 - d^2}{2} = \frac{Q\,D\,v}{g\,(D - d)} = \frac{D\,d\,v^2}{(D - d)\,g},$$

thus disclosing the identity of the two formulas and justifying, to some extent, the reasoning outlined in the premises.

To complete the analogy, it may come to mind that, as water cannot "jump" unless it has a velocity greater than $\sqrt{gd}$, it would be well to demonstrate that the sum of the velocities, v and v_3, is always greater than $\sqrt{gd}$.

Note, from Equation (1), that,

$$\frac{v^2}{g} = \frac{(D + d)\,(D - d)^2}{2\,D\,d}$$

and we are to show that

$$v + v_3 \text{ or } \frac{v\,D}{D - d} > \sqrt{gd},$$

that is, that

$$\frac{v^2}{g} > \frac{d\,(D - d)^2}{D^2}$$

or, eliminating $\frac{v^2}{g}$, that

$$\frac{D + d}{2\,d} > \frac{d}{D},$$

which is obvious so long as $D > d$.

The surge, S, above the level of the quiet water previous to its acceleration into the canal entrance is evidently equal to $D - d - \frac{v^2}{2\,g}$, and it may be shown by calculus methods that the maximum possible value of S is equal to $0.714d$, which occurs for a critical velocity of $v = 7.448\,\sqrt{d}$.

Modifications Involving Friction.—It now seems clear that Equation (1) represents the relation between the depths on each side of the backward rolling wave when friction is neglected. Without attempting to go further into the subject at this time, it may be stated, nevertheless, that the surge probably cannot exceed the value of S derived from this equation, when friction is taken into account. On the other hand, there would seem to be little danger of extravagance if the height of the canal and forebay walls was regulated by the foregoing considerations.

*Proceedings of the American Society of Civil Engineers.

The Swiss Federal Government has definitely decided to electrify the whole of the Swiss railways. The first line to be electrified will be the Erstfeld-Bellinzona section of the St. Gothard line. The cost of electrifying the Federal railways is estimated to be £2,000,000.

Editorial

ANSWERING ONE'S MAIL.

COURTESY: Politeness exercised habitually; an act of good breeding.

That is the gist of a long dictionary definition of the word "courtesy." The meaning of the word is not altered by prefixing "business." Business courtesy shows good breeding. Conversely, people who are well bred always exercise business courtesy.

Are Canadian engineers lacking in business courtesy? Let us most certainly hope that they are not. But certain evidences point to the fact that they frequently come dangerously near business discourtesy. It is discourteous to ignore a civil letter. Yet, how frequently is one compelled to write time and again to Canadian engineers and engineering firms before a reply of any kind is received!

However, we had not thought that this was any more true of Canadian engineers than of engineers in any other country. But an instance just called to our attention gives food for reflection. A well-known business firm wrote to thirty-four municipal engineers in the United States, politely asking for certain easily given information. Twenty-four prompt responses were received. A second letter brought eight more. Seventy-one per cent. answered the first letter; ninety-four per cent. answered either the first or second letter.

Practically the same letter was mailed simultaneously to one hundred and fifteen municipal engineers in Canada. Thirty-two fairly prompt answers were returned. A second letter brought four more. Twenty-eight per cent. answered the first letter; thirty-one per cent. answered either the first or second letter.

Comparisons are invidious, but we feel that the circumstances fully justify the above comparison. This result is absolutely due to carelessness. At heart the average Canadian engineer is as courteous as any other man. But carelessness of this sort is likely to make a very bad impression.

Every civil letter that calls for an answer should have one and have it promptly. Otherwise its recipient is clearly open to a charge of downright discourtesy.

NO FURTHER WATER POWER INVESTIGATION AT PRESENT.

On page 666 of this issue there appears a letter from the secretary of the Economic and Development Commission, giving assurance that the Commission has no intention *at the present time* of conducting any *independent* investigation regarding water powers, as the information now available on this subject will be quite adequate *for present purposes*.

We are very glad that the Commission has decided, for the time being at any rate, not to go into this field. Tremendous scope is afforded the Commission for doing vitally important work along economic lines without delving into engineering subjects at all.

As the Commission obviously was not constituted with a view to doing or reviewing engineering work, the assurance is most pleasing that the lines along which it will exercise its efforts will not be of an engineering nature.

TONNAGE AND SHIPBUILDING.

Of the total tonnage of sea-going ships of the world, namely, 33,531,503, only 62 per cent. is available to-day for the ocean trade of all nations. The nations of Europe engaged in war own over 21,000,000 tons. Of the 17,000,000 tons comprising the merchant marine of the Entente Allies, 65 per cent. is owned by Great Britain. Of the 21,000,000 tons owned by the belligerents, over 4,000,000 tons belonging to the teutonic allies are bottled up in neutral harbors and elsewhere. Of the 17,000,000 remaining, over 50 per cent. has been commandeered to act as transports and supply ships. These are some of the factors which have caused ocean freights to rise to the highest level in history.

In addition, since the outbreak of war, 2,031,000 merchant tonnage has been sunk. New tonnage launched in approximately the same period has been 1,201,638, giving a net tonnage loss of 829,000. Little, if any, increase can therefore be expected in ocean ship space during the war. Even after the war, with a certain amount of tonnage released by various governments, there will be a great scramble for ships for use during the coming commercial campaign.

Therefore, the development of Canadian shipbuilding is receiving considerable attention from capitalists and manufacturers. In an address before the annual meeting of the Canadian Manufacturers' Association, Mr. Thos. Cantley dealt most interestingly with this subject. He pointed out that Canadian shipping carried only a small portion of the lake freights and about one-tenth of the whole produce sent from Canadian ports. He outlined the history of the railways in the Dominion, and deplored the fact that the Government had not carried out a similar policy of assistance in regard to marine transportation.

The canal system has cost over $100,000,000 since Confederation, but it is open to competitors, and over four-fifths of the traffic passing through the canals originates in the United States, while less than one-third of the vessels are Canadian. The Dominion has also spent $150,000,000 on aids to navigation on the coast and inland waters, which are used by all in common, but the Government has done practically nothing towards encouraging the shipbuilding industry. There are a few Canadian shipyards equippped for the building of steel vessels, but they are all on the Great Lakes, and none on the Atlantic seaboard.

Mr. Cantley gave statistics regarding the output of wooden ships in the Maritime Provinces from 1874, when 190,756 tons were built in a year, and the tonnage on the register was 1,158,363, up to 1914, when the vessels built in the year were 43,436 tons, and the tonnage on the register was 932,422. He declared that he had no faith in any scheme for providing greater or more efficient transportation through Government ownership, time charter or operation of a tramp steamer fleet, or by any other form of attempted control of ocean traffic by the Government, but considered that the Government would be justified in making a considerable expenditure to aid in the development of shipbuilding at present.

The iron and steel industry of Canada could never have reached the present output capacity save for the fostering influence of the combination of tariff protection

and bounty. Steel shipbuilding on a comprehensive scale can be developed if the Government is prepared to grapple with the matter in a farsighted and liberal manner. It is generally admitted that it requires from five to ten years to build up any good manufacturing organization, and this makes it necessary that any plan of assistance should be guaranteed for a period long enough to enable new yards to get their organization well established.

TWO-INCH WOOD BLOCK PAVEMENT.

In October, 1913, a 100-foot strip of experimental paving was laid in one of the residential streets of Tacoma, Wash., using creosoted wood blocks only 2 inches deep. Inquiry last month by *The Canadian Engineer* brought a reply stating that the pavement is, in general, in good condition. "There has been no heaving. A portion of the pavement which was laid on a concrete base that had a sidewalk finish, has apparently separated from the foundation, but this could be prevented in future work. The blocks showed excessive bleeding, but this also could be prevented by different treatment.

"The street receives very heavy traffic for a residential street, inasmuch as it is the only one used for carting between the two main streets of Tacoma, and it is on the right-hand side leading out of the city, thus getting the traffic of the heavily loaded teams. With the exception of where the joint was made with the asphalt paving, and which slipped up over the blocks, necessitating the cutting away of the asphalt, no expenditure has been made for up-keep on this experimental pavement."

If creosoted wood block only 2 inches deep proves practical, a new field will be opened for this type of paving on account of the great reduction in cost that will be possible. The blocks laid at Tacoma were only 1⅞ inches wide by 3⅞ inches long. They were Douglas fir, treated with approximately 18 lbs. per cubic foot of creosote. On account of the small size, excellent penetration and uniformity of grain were more easily obtained than with blocks of standard size.

The blocks were laid on a concrete base 14½ feet wide. The pavement was divided into four sections, each 25 feet long, as follows:—

(1) Blocks laid with long axis at right angles to the line of traffic, on a 1" sand cushion; broken joints, blocks rammed tight.

(2) Blocks laid at an angle of 67½ deg. to line of traffic, on a 1" sand cushion; rammed tight and joints broken as in Section 1.

(3) Blocks laid on a 1" cushion made of one part of cement to three parts of fine sand, mixed and spread dry; blocks laid with long axis parallel to the curb, making unbroken joints along the line of traffic; at right angles to the curb, joints are broken.

(4) Blocks laid in the same manner as in Section 3, excepting that they are bedded in grout of 1 part cement to three parts sand, mixed wet enough to take a smooth trowel finish.

The crushing strength of 2-inch blocks is said to be approximately as great as the crushing strength of the larger blocks, and as there is not likely to be two inches of actual wear during the lifetime of the pavement if the blocks do not rot, break or crack, the 2-inch block would seem to be feasible with proper treatment, provided that they are made so small that the impact of traffic will not break them. The cost of laying the smaller block would, of course, be somewhat higher than the cost of laying the larger block, but this would undoubtedly be far more than offset by the reduced cost of the materials. The further progress of the Tacoma experiment undoubtedly will be watched with interest by municipal engineers.

LETTER TO THE EDITOR.

"Another Water Powers Investigation?"

Sir,—My attention has been called to your editorial in June 1st issue, "Another Water Powers Investigation," in which you expressed the belief that the Economic and Development Commission was about to investigate the water powers of the Dominion.

In justice to your readers who may be interested in this matter, I should be obliged if you would state that the Commission has no intention at the present time of conducting or having conducted any independent investigations regarding water powers.

Cognizance has been taken of the results obtained by the Water Power Branch of the Department of the Interior, and by provincial authorities who have conducted similar investigations. It is evident that the information now available on this subject will be quite adequate for present purposes.

Yours very truly,

(Signed) W. J. BLACK,

Secretary, The Economic and Development Commission.
Ottawa, June 14th, 1916.

UNDERGROUND CANAL DUG.

Despite the war and the tremendous burden it has put upon France, a tremendous undertaking, which was started long before any one suspected that there would be a war, has just been completed and France now possesses the longest underground waterway in the world. This is the Rove Tunnel from Arles to Marseilles, which was inaugurated last week.

This wonderful waterway runs through a mountain and below two communes. It is 72 feet broad and from the canal bottom to the summit of the vault its height is 46 feet. There will be ten feet of water in the canal, so from its surface there will be a clear space overhead of 36 feet. To put it otherwise, the section of the tunnel is six times that of our ordinary tunnel. To add another touch, it may be said that twice as much detritus has been shovelled out to make this underground passage as came from the Simplon Tunnel.

The canal is not yet finished. As yet the bed of the Rove Tunnel is dry, though it is pierced through all its length. It will take three years before it is ready for traffic, but when the work is done Marseilles will join hands with Havre for the first time.

WILL DOUBLE PLANT.

The Armstrong-Whitworth of Canada, Limited, has awarded contracts for the doubling of its already extensive plant at Longueuil, Que., at an estimated cost of $750,000. The new plant will comprise a plant for the manufacture of steel tires for locomotives and passenger rolling stock, as well as for the rolling of steel wheels and the manufacture of forged axles. The company will also add a rolling mill and provide for the making of special rounds and shapes, all made for electric smelted steel, while rough drills and material of that class will also be made. This is the first time the manufacture of steel wheels has been attempted in Canada, but this is done to meet the now heavy demand for such wheels, which are necessary to carry cars of 75 tons weight.

MONTREAL AQUEDUCT SCHEME.

Controller Villeneuve, of Montreal, whose motion to appoint experts to report on the proposed aqueduct power development was defeated by his fellow controllers, is making a strong endeavor to get the desired information in another manner. Taking advantage of his "parliamentary privileges," he has given motion that he will ask a certain series of questions regarding the aqueduct, at a future meeting of the board. Mayor Martin stated that if necessary the whole staff of the various departments interested would be set to work to answer the questions. It is expected that answers will be ready within a fortnight. The questions asked by Controller Villeneuve are as follows:—

1.—Names of the experts, and date of their appointment, who have approved, or only examined the figures on the debit of the tailrace, as planned for the new enlargement, contract No. 2?

2.—By whom were those figures calculated, verified, and at what date? Do such figures show the depth, width of section of tailrace, its slope in longitudinal profile, and that the back water of the St. Lawrence has been studied well enough in 1913 so as to establish a permanent flow of all the water passing through the turbines, without changing the height of the waterfall at the power-house and the amount of power? and without an excess of current that would be damageable to the tailrace?

3—If such calculations have not been made or verified as exact by experts, was it possible to determine the measurements of the enlargement of the tailrace and how can one be assured that the tailrace will be able to take care of all the water coming from the canal, without causing eddies that will be dangerous to the plant?

4.—On what basis, on what calculation, on what type of plant, on what selection of machinery and equipment, on what dimensions of plant, buildings, installation, are based the figures for the settling basis at the wheel-house? When was that basin excavated?

5.—Whether the kind of plant, the type of machinery, the power of installation, the plans for a plant, have or have not been studied, calculated and prepared, how was it possible to give contracts for excavating the basin and the tailrace, and have the basin dug out on imaginary measurements?

6.—On what selection of machinery, on what kind of plant and electric installation, on what disposition of buildings, on what plans, specifications, studies and projects, were based the estimates of the approximate cost of the power-house, pumping plant and electric plant, and the figures reported to the Board and the Council to the support of a demand of a credit, showing the total cost of the undertaking and the cost price of one hydraulic h.p.?

7.—After the study made up to this date, by the engineers of the aqueduct as to the plant of a power-house, a pumping house and a central electric station, can the department estimate, within a million dollars, the probable cost of the work and the installation to the plant to be erected and equipped?

8.—If no serious and careful estimate was ever made, how can the superintendent of the aqueduct estimate the probable cost of a hydraulic h.p. and the cost price of lighting, declare it advantageous and economical, that is, municipally not prohibitive under local conditions at Montreal?

9.—To what did the department estimate the annual expenditure of the operation and maintenance of the new power? These permanent charges are:—

(a)—Salaries of operators and guardians.
(b)—Maintenance, lubrification, repairs to machinery, buildings and canals.
(c)—Sinking fund on buildings, machinery, transmission lines, canals, bridges, fences and roads.
(d)—Interest on capital invested since 1906 or 1907 (not including filtration plant).

10.—What is the gravity of the accident to the intake? What soundings had been taken before ordering that structure? By whom? What was the nature of the soil in the foundations? Who has superintended, inspected and accepted that work? Who signed the orders for payment? Were any extras paid to the contractors for rock excavating? When will be made the necessary repairs?

11—What is the amount payable by the city, for repairing the concrete conduit after the accident of 1913? Has the amount been paid? Who was it paid to?

Who was found responsible for the accident? Who passed judgment on the damages and the responsibilities?

12.—What is the annual salary for engineers, draughtsmen, chainmen, surveyors, inspectors, clerks, etc., paid by the department to parties employed permanently in connection with the enlargement of the aqueduct (not including the filtration plant): (1) for 1913, 1914; (2) for 1915, for the five months of 1916.

13.—Are the engineers in charge of the filtration plant also in charge of the aqueduct? On what scale are they paid; what is the monthly total expenditure on the aqueduct and the filtration plant?

14.—At what was ever estimated the project of municipalizing the lighting, the cost of aerial or underground lines for transmission and distribution of electricity?

15.—What are the fixed charges per month, for operating the Laval pump (pump No. 8) and the boiler connected with it? (a) Salary of engineer and fireman; (b) Cost of coal for boilers operating that pump; (c) Lubricating and light; (d) Maintenance and repairs of machinery; (e) Wear and tear and sinking fund.

16.—What is the number of bridges to be erected on the canal and what is their approximate cost?

17.—What will be the approximate cost of the boulevards? How much land was given free of cost to the city and how much there is to be expropriated? Where are we at with the whole expropriation of the boulevards?

18.—Has the cost of an auxiliary steam plant been calculated?

19.—What will be that cost?

20.—Has an adequate study been made of the work to be done at the intake to prevent obstruction of the canal frazil and to insure the deviation of floating ice. What was the estimated cost of that work in 1913; on what mode of construction and on what calculation was based the estimation? Were any experts consulted on the subject?

Controller Villeneuve requested the city comptroller and auditor to supply the following information to the Board:—

(a) A statement of the accounts spent since 1906 for the aqueduct.

1. The concrete lateral conduit. 1, contract for conduit and accessories; 2, purchases of land or expropriations for the conduit; 3, salaries of engineers, inspectors, office clerks, etc., for 1906-1909; 4, compensating basin, for twin conduit; 5, gate basin at the intake; 6, intake in the River St. Lawrence.

2. Widening the canal (contract No. 1); 1, Quinlan and Robertson, contract and extras; 2, salaries of engineers, inspectors, offices, instruments, etc., 1909-1913.

3. Widening the canal (contract No. 2), Cook Construction Co. 1, amount of tender; 2, amount paid to date. Amount claimed by the Cook Construction Co. for extras and damages.

4. Salaries of engineers, inspectors, offices, instruments, etc., (1913 to date).

(b) What is, to date, the capital engaged in the widening of the aqueduct (not including the filtration plant).

What is the amount of interest already paid on that same capital, either engaged or spent? What is the average rate of interest?

What is the amount still available on the loans authorized to that end?

(c) What round figure is represented by the capital engaged in the steam pumping station of Centre Street (complete)? (a) buildings and chimneys; (b) machinery (pumps and engines), bridges; (c) steam tubing. Is there a sinking fund for depreciation and renewal?

(d) What are the total and fixed charges per annum for the operation of the low level steam pumping plant? (a) Salaries; (b) oil, upkeep, repairs; (c) total annual disbursements for coal. The above covering the year 1915.

(e) What was the cost of the last thirty million gallon pump installed? (a) Complete cost of machinery, installed; (b) cost of buildings and foundations; (c) cost of the last row of boilers; (d) cost of the boiler house; (e) cost of the last brick chimney.

(f) What is the total annual amount of charges paid by the city to electric light and power companies for (a) for lighting streets, parks, etc.; (b) for lighting municipal buildings; (c) for motive power in pumping stations, shops, etc.?

PERSONAL.

Capt. G. H. BLACKADER, a member of the firm of Barott, Blackader & Webster, architects, Montreal, has been reported wounded in the recent fighting.

C. C. JOHNSTON, formerly resident engineer at London, Ont., for Chipman & Power, of Toronto, has joined the Canadian Copper Co. at Sudbury, Ont.

H. G. ACRES, B.A.Sc., hydraulic engineer of the Ontario Hydro-Electric Power Commission, has received the degree of M.E. from the University of Toronto.

W. G. CHACE, chief engineer of the Greater Winnipeg Water District, has been elected chairman of the Winnipeg branch of the Canadian Society of Civil Engineers.

Lieut.-Col. RAMSAY, engineer, C.P.R., was among those who received birthday honors conferred by King George, receiving the C.M.G. for organizing the railway construction corps.

E. HANSON, city electrical engineer, Saskatoon, Sask., recently read a paper entitled "Power Development in Saskatchewan" before the members of the Utilities Engineering Society of Saskatoon.

J. T. JOHNSTON, Assoc.Mem.Can.Soc.C.E., chief hydraulic engineer of the Water Power Branch, Department of the Interior, received the degree of C.E. from the University of Toronto last Friday.

LEONARD METCALF, consulting engineer, of the firm of Metcalf & Eddy, Boston, has been elected president of the American Waterworks Association, to succeed Nicholas S. Hill, Jr., whose term of office expired.

J. C. JOHNSTONE, town engineer, Port Alberni, B.C., now in France with the Canadian Engineering Corps, has won his commission on the field. In the latest report he expected to return to England for a short time on leave.

JOHN J. DEWHIRST, a prominent engineer and road builder of Essex County, has tendered his services to the Canadian Government to head a construction corps now being recruited to build railways, bridges and roads in the war zone.

J. A. McCULLOCH, formerly sales manager of the Manitoba Bridge and Iron Works, Limited, Winnipeg, has been appointed general superintendent of the company, to succeed Mr. E. Stewart, who has been compelled to resign owing to ill-health.

C. D. HOWE, chief engineer of the Dominion Grain Commission, will deliver an address this evening on "Terminal Grain Elevator Construction" at a joint banquet of the Regina Engineering Society and the Regina Branch of the Canadian Society of Civil Engineers.

Lieut.-Col. A. CLYDE CALDWELL, commanding Royal Canadian Engineers in the 2nd military district, has been promoted to the important post of officer administering Royal Canadian Engineers for the whole Dominion. His headquarters will be at 215 Simcoe Street, Toronto.

OBITUARY.

JOSIAH MASON, a well-known Brampton (Ont.) contractor, died recently at his home in that town.

JOHN W. MESSACAR, building contractor, passed away recently at his home in Hamilton, Ont., at the age of 59 years.

CHARLES R. SCOLES, a prominent railroad man of New Carlisle, Que., died recently in Bermuda. The deceased was born at Grantham, England, in 1856. He was connected with various railway enterprises in Eastern Canada. In 1890 he was appointed manager of the Salibury & Harvey Railway. In 1900 manager of the Atlantic and Lake Superior Railway and in 1911 manager of the Quebec Oriental and Atlantic, Quebec and Western Railways.

S. H. REYNOLDS, M.Can.Soc.C.E., chairman of the Greater Winnipeg Water District Commission, died suddenly last Friday night in Chicago. Mr. Reynolds had seemingly been in perfect health, and it is thought that death resulted from an acute attack of heart trouble. He was appointed to the Winnipeg commission early in October, 1913, and was the first member of the commission to be appointed. At that time he was a resident of Victoria, B.C., and had been engaged for a number of years in mining pursuits. He had been assistant city engineer of Winnipeg for some years under Col. Ruttan, resigning from that position in 1907. He was elected to full membership in the Canadian Society of Civil Engineers on March 12, 1908.

DUST.

The following very good editorial appeared in a recent issue of The Ottawa Journal:—

It is time Ottawa took up in earnest the matter of oiling the roadways. This is a beautiful city, but a dirty one; and not mud but dust does the worst mischief.

Dust is bad for the lungs.

Dust is bad for the eyes and ears and nose.

Dust is bad for the skin.

Dust is bad for the temper.

Dust is bad for shop goods, and bad for shop windows.

Dust is bad for housekeeping.

Motor cars are desperate dust-producers. Dust gets back at them with grit and dirt, injures them and worries their owners.

If this dust infliction had to be endured—if there were no recourse against it—all of us could go on grumbling as we do now, and no one would be just to call us silly. Much of it does not have to be endured. Sprinkling the streets, or some of them, with oil will stop a great deal of the nuisance. Sprinkling with water stops some, of course. But sprinkling with oil is a very great deal more effective; nor is it much more expensive. It is not so expensive but that the Ottawa Improvement Commission, which is careful and sensible with its money, is able to oil the park driveways. It is not so expensive but that many cities are able to practise it.

Oiled roadways in this city would add vastly to the comfort, the health and the pleasure of the people. The Board of Control should take a real try at this question.

Mr. Paul Janoushevsky, of the Vladicaucase Railway, Russia, has been visiting Vancouver, B.C., and Portland, investigating the construction of bridges. On his return to Russia he will superintend the construction of the first direct lift bridge to be erected in that country.

The Jeffrey Manufacturing Company of Columbus, Ohio, announce the re-opening of their Northwestern Branch Office at Seattle, Wash., and the appointment of Percy F. Wright, Consulting Mechanical Engineer, as District Manager for British Columbia and Alberta.

Volume 30. Toronto, June 29, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS

A BRIEF REVIEW OF WATER RESOURCES PAPER No. 3, AN OFFICIAL PUBLICATION OF THE DOMINION WATER POWER BRANCH, COVERING THE DEPARTMENTAL INVESTIGATIONS INTO THE POWER RESOURCES OF THE WINNIPEG RIVER WATERSHED.

PART III.

As typical of the detailed character of the investigations of the Dominion Water Power Branch into the proposed power concentrations on the Winnipeg River, and as indicating briefly the manner in which the data secured and compiled has been made available to the public in "Water Resources Paper No. 3," the following notes from the report on the proposed concentration at the Du Bonnet Falls have been prepared.

After full consideration of all aspects, the river reach in question was divided into three proposed concentrations—Pine, Du Bonnet and McArthur respectively. The Du Bonnet concentration includes the natural drop at Whitemud, at Little du Bonnet and at Grand du Bonnet Falls.

Model of Proposed Du Bonnet Layout.

Head and Tailwater Elevations. — The headwater at the proposed Du Bonnet plant has been placed at elevation 808. This will result in a 4-foot rise in the present normal water level at the head of the falls, and will flood back to the foot of the second McArthur Falls.

Flooding.—Little flooding will result from raising the headwater to elevation 808. An embankment is necessary on the west side. This embankment is designed with a 10-foot top at elevation 815, and with 1½ : 1 slopes. It is 800 feet in length, and at regulated level in the pond will withstand a head of from 5 to 7 feet at its heaviest sections.

Pondage.—A regulated level of 808 will create 1,700 acres of pondage. A draw of 1.7 feet on this pond will supply a four-hour peak load to the full installation considered, *i.e.*, 140,000 horse-power, assuming a continuous flow of 20,000 second-feet in the river. While this provides very fair pondage facilities, they are not as favorable as the conditions at the majority of the sites proposed along the river.

Ice Conditions.—During the winter season the channel in the vicinity of island No. 2, below the Little du Bonnet Falls, becomes at times somewhat choked with a deposit of frazil and anchor ice. This is largely due to the long stretch of agitated water in the Grand and Little du Bonnet Falls, presenting ideal conditions for the formation of frazil and slush ice. The contracted river channel in the vicinity of the island, together with this formation of frazil, forms a combination favorable to the formation of an ice barrier, and is at times the cause of more or less choking and consequent raising of the water level above.

Layout.—The general layout (Fig. 1) connects with contour 815 on the right bank by means of a corewall embankment, ice sluices, and power station joined direct with a sluice and spillway dam of solid gravity section arched in plan so as to follow the high rock above the falls, and finally closes with the high land on the opposite bank by means of a second embankment.

East Embankment.—The east embankment has been estimated with a 15-foot top at elevation 815, and 1½ : 1 slopes, constructed from the material most readily available. Impermeability is secured by a concrete corewall with a 1-foot crest at elevation 814; and a batter of 1 : 12. This core will be bonded to the bedrock should the latter be within reasonable distance of the surface, and if not, a tight and safe bond can readily be obtained with the clay subsoil.

Ice Sluices.—Between the east embankment and the power house are located three 20-foot sluices with sills at

elevation 793. These serve the double purpose of providing a suitable ice run and additional discharging capacity to the whole layout. The sluices are so placed as to clear the forebay of ice and drift by tending to produce a current parallel to the line of the power station. It has been assumed that rock will be available for the foundation at elevation 775 under the easternmost sluice, and at 770

(1) Initial Development.—This consists of the seven 10,000-horse-power units next the dam. It will provide for the utilization of 12,000 second-feet at 46-foot head, with the turbines running at eight-tenth gate.

(2) Intermediate Development.—This consists of twelve 10,000-horse-power units, the additional five being adjacent to the initial installation. Twelve units will pro-

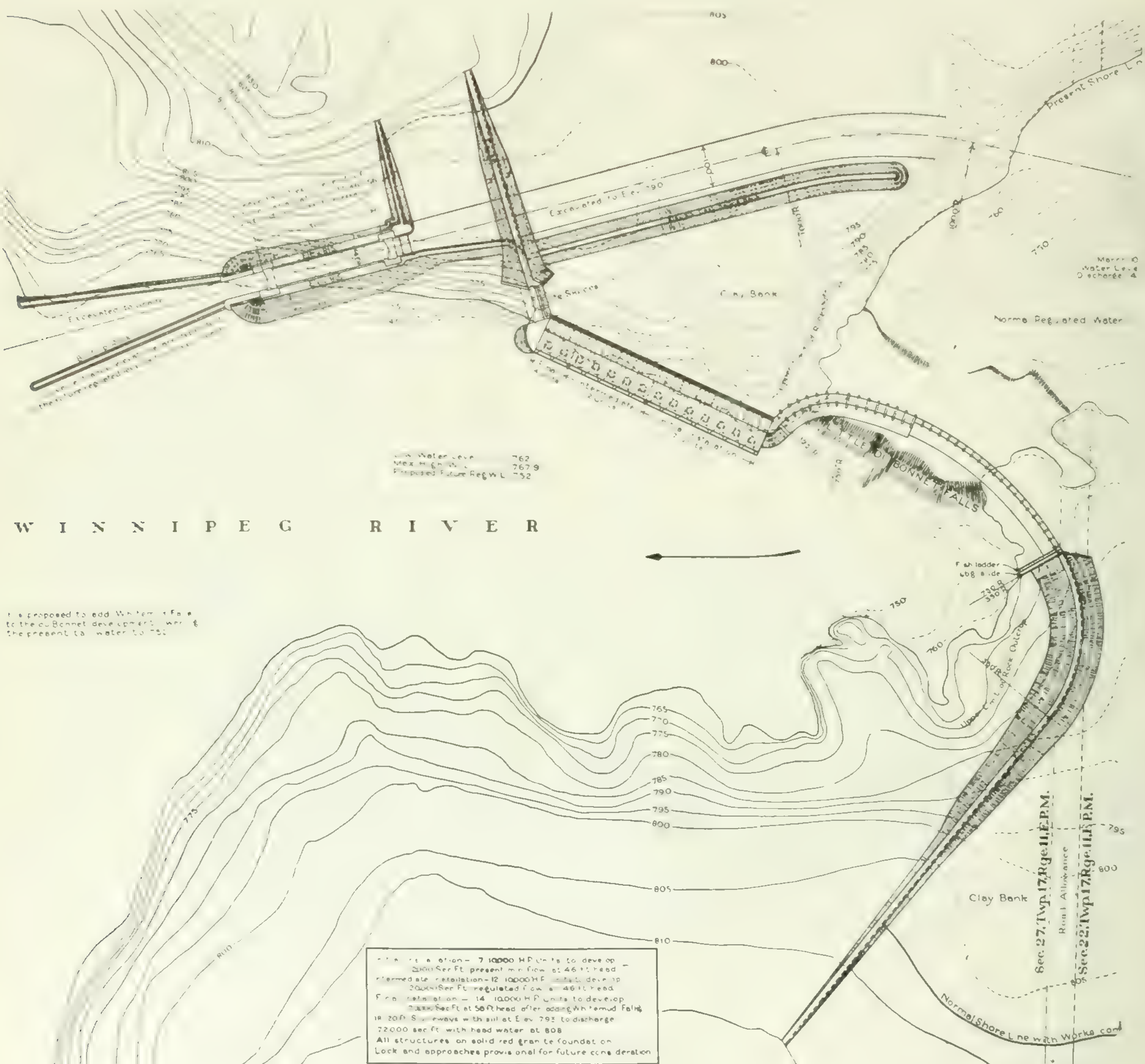


Fig. 1.

under the remaining two. It is exposed on the river bank at the latter elevation.

Power Station.—The power station (Fig. 2) has been designed for single runner vertical turbines of 10,000 horse-power at full gate. The section has been developed only in sufficient detail to enable a fairly accurate estimate being made of the quantities involved. This was mainly a question of the size of the water passages to carry the requisite supply at permissible velocity to and from the turbines.

vide for the utilization of 20,000 second-feet at a 46-foot head, with the turbines running at eight-tenth gate.

(3) Final Development.—This consists of fourteen units which will provide for the utilization of 20,000 second-feet at 56-foot head with turbines at eight-tenth gate.

Sluiceway Section of Dam.—Fifteen 20-foot sluiceways with sills at elevation 793, are immediately adjacent to the power station. The sluiceway deck, with its underside elevation at 813.5, will permit of a 5½-foot rise in

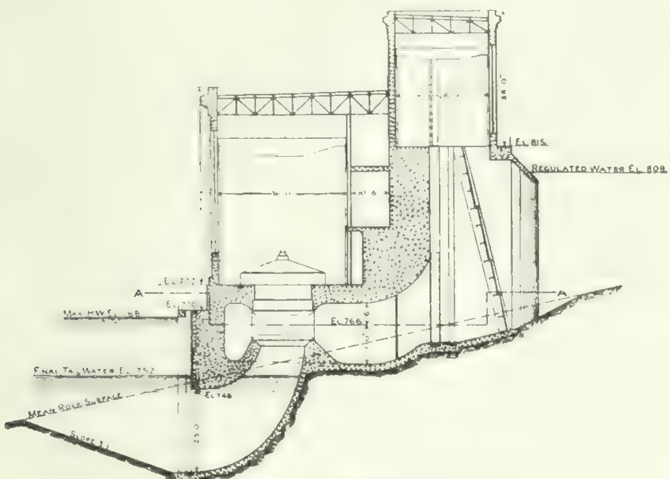
the regulated level. Solid rock underlies the sluiceway section. Its elevation has been assumed at 765.

Spillway Section of Dam.—The spillway section of the dam, 400 feet in length, has its crest at elevation 808, and is surmounted by a 10-foot platform supported by 3-foot piers, spaced 23 feet centre to centre. The platform will give ready access to the plant from the rail connection on the west bank.

Discharge Capacity.—At regulated level the fifteen sluiceways and three ice sluices will discharge 72,000 second-feet. In addition to this the completed power station will pass an additional 20,000 second-feet, which, although not a source to be relied upon at all seasons, may be considered as a safety factor.

A free spillway, 400 feet in length with crest at 808, provides for automatic regulation. Three feet over this crest, with all sluiceways open and the power station in operation, gives a total discharging capacity of 113,000 second-feet. Five and one-half feet above the spillway crest can be carried by all structures.

Model of Proposed McArthur Layout.



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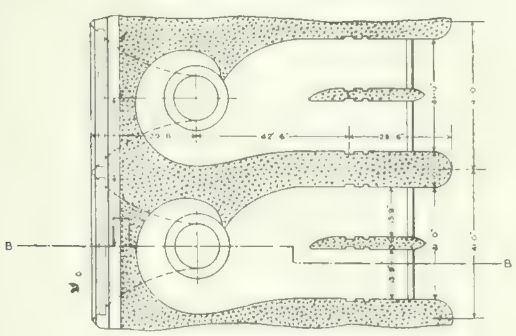


PLAN ON LINE A.A

Fig. 2.

Estimates of Cost.—The estimates place the power on the switchboard in the power station, and do not include transmission. It is considered that the assumptions which have been necessary are more than warranted. Actual construction will possibly lead to a considerable reduction in the totals submitted, as it has been considered advisable at all points where any reason for doubt exists, to make the most liberal provision for eventualities.

The estimates include a 13-mile spur line from the present terminal of the Canadian Pacific Railway at Lac du Bonnet. This will bring rail connection to the west bank of the river. An item has been included for the construction of a ferry for the transport of loaded cars across the river to the power station site.

In addition to the above, 10 per cent. has been added for contingencies, 5 per cent. on this total for engineering and inspection, and 5½ per cent. on the whole for one year for interest during construction. The estimated cost of the Whitemud Falls excavation has been inserted as a unit.

The annual operation costs include capital charges, and represent the cost of operation at the power station. They do not include transforming and transmission.

Du Bonnet Site.—(1)—Initial Development. (Seven 10,000-h.p. Units.)

Capital Cost of Installation.

Dam and equipment	$ 542,000
Embankment (flood protection)	5,000
Ice sluices	72,000
Power station and equipment	657,000
Hydraulic installation	665,000
Electrical installation	805,000
Railroad	156,000
Ferry	50,000
Permanent quarters	25,000
Contingencies, 10%	298,000
Engineering and inspection, 5%	164,000
Interest during construction, 5½%	189,000
Total initial cost	$3,628,000

Twenty-four-hour power available at 75% over-all efficiency = 47,000 h.p.
Capital cost per twenty-four-hour h.p. = $77.19
Capital cost per installed h.p. = 51.83

Annual Cost of Operation.

Interest, sinking fund and depreciation charges:	
Interest, 5½% on $3,628,000	$200,000
Sinking fund, 4% (40-year bonds)	38,000
Depreciation: 1% on permanent works = $12,000; 4% on machinery, etc., = $64,000.	76,000
Operation charges: staff = $21,000; supplies = $20,000	41,000
Total annual charge	$355,000

Annual cost per h.p.-year, 24-hour power = $7.55
Annual cost per h.p.-year, machinery installed 5.07
Annual cost per kw. hour = 0.115 cent
Annual cost per kw. hour on basis of 50% load factor = 0.230 cent

(2)—Intermediate Development. (Twelve 10,000-h.p. Units.)

Capital Cost of Installation.

Dam and equipment	$ 542,000
Embankment (flood protection)	5,000
Ice sluices and roadway	72,000
Power station and equipment	926,000
Hydraulic installation	1,140,000
Electrical installation	1,380,000
Railroad	150,000
Ferry	50,000
Permanent quarters	25,000
Contingencies, 10%	430,000
Engineering and inspection, 5%	236,000
Interest during construction, 5½%	273,000
Total intermediate cost	$5,235,000

Twenty-four-hour power available at 75% over-all efficiency = 78,500 h.p.
Capital cost per 24-hour h.p. = $66.69
Capital cost per installed h.p. = 43.62

Annual Cost of Operation.

Interest, sinking fund and depreciation charges:	
Interest, 5½% on $5,235,000	$288,000
Sinking fund, 4% (40-year bonds)	55,000
Depreciation: 1% on permanent works $14,000; 4% on machinery, etc., = $106,000	120,000
Operation charges: staff = $27,000; supplies $32,000	59,000
Total annual charge	$522,000

Annual cost per h.p.-year, 24-hour power = $6.65
Annual cost per h.p.-year, machinery installed = 4.35
Annual cost per kw. hour = 0.102 cent
Annual cost per kw. hour on basis of 50% load factor 0.204 cent

(3)—Final Development. (Fourteen 10,000-h.p. Units.)

Capital Cost of Installation.

Dam and equipment	$ 542,000
Embankment (flood protection)	5,000
Ice sluices and roadway	72,000
Power station and equipment	1,035,000
Hydraulic installation	1,330,000
Electrical installation	1,610,000
Railroad	150,000
Ferry	50,000
Permanent quarters	25,000
Contingencies, 10%	483,000
Engineering and inspection, 5%	265,000
Interest during construction, 5½%	307,000
Whitemud Falls rock-cut	671,000
Total final cost	$6,551,000

Twenty-four-hour power available at 75% over-all efficiency = 95,500 h.p.
Capital cost per 24-hour h.p. = $68.60
Capital cost per installed h.p. = 46.79

Annual Cost of Operation.

Interest, sinking fund and depreciation charges:	
Interest, 5½% on $6,551,000	$360,000
Sinking fund, 4% (40-year bonds)	69,000
Depreciation: 1% on permanent works $15,000; 4% on machinery, etc., = $123,000	138,000
Operation charges: staff = $30,000; supplies = $38,000	68,000
Total annual charge	$635,000

Annual cost per h.p.-year, 24-hour power = $6.65
Annual cost per h.p.-year, machinery installed = 4.54
Annual cost per kw. hour = 0.102 cent
Annual cost per kw. hour on basis of 50% load factor = 0.204 cent

COST OF MAINTAINING NEW YORK STATE HIGHWAYS.*

By **Fred W. Sarr,**
Deputy Commissioner, New York State Highway Department.

UPON receiving your kind invitation to be with you to-day and address you on the subject of highways, I was at first reluctant to accept same owing to the voluminous and important work which has been before the Commission during the past few months. In finally accepting, however, I did so with the idea in mind of addressing you on the subject of the maintenance and repair of improved highways in the State of New York, which end of highway engineering in that State, I am at present associated with.

The proposition of maintenance of improved highways in New York State is an enormous one, practically ninety millions of dollars having been spent by the State for the construction of roads in the past seventeen years, and yet, with this huge expenditure, the experience gained and the system now in force, the maintenance of highways, even in our great State, is, I might say, still in its infancy. The evolution in the kind of traffic to which our roads are subjected, particularly the adoption of the use of motor trucks carrying very heavy loads, and the general increased traffic necessitates a continuous study of individual cases.

General maintenance is comprised of keeping the paved roadway surfaces in as nearly uniform condition as possible, due regard being had for the relative importance of each particular road and the character of traffic it bears; keeping the earth shoulders smooth and safe for traffic; the drainage system free from obstructions; all structures in good repair and removing obstacles to vision, as brush or overhanging branches.

If the work of maintenance of improved highways is consistently performed throughout successive years, it is certain that the efficient life of such roads will be lengthened, and it would appear as though it could be prolonged almost indefinitely, if year by year the material added to the paved surface be equal or a little in excess of the material which has worn away during the same interval of time. This applies to the macadam type of construction which constitutes the vast bulk of the mileage under maintenance.

Maintenance should commence when construction leaves off, because in order to effectively and economically maintain improved roads it is necessary that the roadway be in a good state of repair at the time the maintenance work begins.

As an illustration of the magnitude of highway construction and maintenance in New York State, there were on April 1, 1915, 5,345 miles of improved and accepted state and county highways, and this mileage was increased as the season advanced, and on December 31, 1915, there were 5,926 miles of improved and accepted highways which has been maintained and repaired.

*Read before the Third Canadian and International Good Roads Congress, March, 1916.

The following is a summary of the maintenance and repair work performed during the past season, including sums obligated on uncompleted contracts:

276 miles of highway resurfaced or reconstructed at an average cost of approximately $5,471 per mile; total expenditures and obligations under this item	$1,510,112
2,086 miles of highway given a surface treatment of bituminous material and cover of sand, fine gravel, iron ore tailings or fine crushed stone, at an average cost of $419 per mile; total expenditure and obligations under this item	874,137
728 patrolmen employed in the work of maintenance and minor repairs, at a total cost for labor	403,047
Expended for material and temporary labor in making miscellaneous repairs and supplying material to patrolmen for maintenance	998,462
Expended for rentals of large units of repair equipment	58,135
Expended for purchase of equipment and tools	31,958
Expended for engineering, supervision, inspection and expenses incidental thereto	334,724
Total amount expended and obligated for all purposes, approximately	$4,210,575

The State Highway Law, or our authority, provides for the maintenance and repair of improved highways either by contract or departmental forces, and all work which can be properly anticipated and foreseen, is incorporated into contracts which are awarded to the lowest responsible bidder, and emergency work and work of a minor nature, particularly such repairs as cannot be definitely measured or expressed in contract units, is performed by departmental forces.

During our past working season there were 230 maintenance contracts prepared, advertised and awarded to the lowest responsible bidder for a sum aggregating $2,271,566.59, or 61 per cent. of the total amount expended.

There was expended directly by the department for materials, labor, rental and purchase of equipment and tools, the sum of $1,604,285.

A study of the experience of our Maintenance Department in maintaining and repairing highways during the past year indicated that the expenditures are divided into three groups:

First. Maintenance, or the act of maintaining and preserving the various features of the highway in the same or uniform condition; the cost of such maintenance of all the improved highways of all types was approximately $350 per mile, which involves the cost of the patrol system and the material used by the patrolmen, together with the cost of the surface treatments with bituminous materials and cover and supervision.

Second. Repair, or the act of restoring the highway to its former condition after more or less extensive deterioration during the winter season with the contingent freezing, thawing, unstable foundation, obstructed drainage, floods, washouts, sliding banks, etc., and that the cost of such emergency repairs was approximately $140 per mile for roads of all types.

Third. Reconstruction and resurfacing. While on many of the improved highways it appears possible, with efficient maintenance, to preserve a standard of improvement from year to year, there are those that show marked deterioration in spite of efforts at maintenance and extensive repairs from time to time. This deterioration is generally due to peculiar traffic conditions, combined with unsuitable materials used in the original improvements, and is often the result of insufficient foundation material in the roadbed.

The total amount expended and obligated for all purposes in the year will average $750 per mile when distributed over the entire mileage of improved highways.

This statement is misleading in that a large percentage of the total improved mileage is of recent construction.

The first highways improved by the State under the Higbie-Armstrong Act were completed in 1899, and in thirteen years, or to the end of 1911, there had been completed and accepted but about 2,600 miles, while in the last four years there have been completed and accepted 3,226 miles. In other words, 55 per cent. of the improved mileage has been constructed an average of two years, while the 45 per cent. has been improved an average of ten years.

Assuming that no pavements should require resurfacing for a period of four years after construction, it is necessary to eliminate the 3,226 miles which have been improved during the past four years from the consideration of the cost per mile for resurfacing and reconstruction. Therefore, the total expenditure for this subdivision of the work should be distributed only on such mileage as has been constructed or improved for a period of four years, and when so distributed the cost per mile for this subdivision during the past year is approximately $560 per mile.

It would seem, however, that the average life of a pavement after reconstruction would be greater than that of the first improvement, as foundational weakness that has developed would be provided for in the reconstruction. Also, the maintenance and repairs for the first five years after the original improvement are greatly increased by heavy items which are properly chargeable to improvement, and are really a completion of the improvement, such as removal of slides from banks which have been cut into at the time of improvement; the construction of retaining walls to sustain such banks, and for the protection of the highway from the erosion of streams. Also the drainage conditions, as provided in the original improvement, are often the subject of much complaint from the abutting owners and necessitate modifications and construction of storm water sewers, all of which develop and are taken care of in the first few years, after the original improvement. It can, therefore, reasonably be expected that the cost of maintenance repairs and reconstructions will decrease in some proportion to the age of the improvement and that the high cost of $560 per mile for resurfacing and reconstruction, when applied to all the improved highways, would never be attained, and that the reduction in the item of repair would offset the increase in reconstruction as the improvements increased in age owing to the gradual elimination of weakness, together with the effect of efficient maintenance.

It would accordingly seem by this manner of reasoning that the improved State and county highways of all types could be perpetually maintained for about $750 per mile.

Our expenditures for the past have been segregated into groups to determine the expense of maintaining the roads of various types, the expenditures in each instance being charged to the type in which the highway was classed at the beginning of the season or before reconstruction.

There were under maintenance during the season 192 miles of gravel roads, upon which the average expenditure, including reconstruction to a different type, was $955 per mile, and the average expenditure, exclusive of recon-

struction, was $577 per mile. Gravel roads, while most susceptible to deterioration under heavy traffic, are most easily and readily repaired. Said repairs are generally accomplished by scraping and honing in the spring and the addition of new material from gravel banks in the vicinity.

Surface treatments have been given to gravel roads, but are not generally satisfactory where any considerable traffic prevails. The treated gravel surface is soon converted into longitudinal ruts and ridges by displacement, and this condition is not as easily repaired after the surface has been treated. Where medium to heavy traffic prevails it appears preferable to lay a new macadam surface over the existing gravel, and this practice for the past season results in the heavy expense for reconstruction of this type.

There were under maintenance during the past season 2,298 miles of so-called waterbound macadam highways, upon which the average expenditure, including resurfacing and reconstruction, was $1,055 per mile, and the average expenditure, exclusive of resurfacing and reconstruction, was $564 per mile.

The expenditures on this type of pavement are larger than on any other type, both for maintenance and reconstruction. This is partially due to the fact that the average age of this type is greater than that of any other type. The maintenance is more expensive owing to the necessity of more frequent surface treatments and to the necessity for constant patching. The large charge for resurfacing is due to the large number of miles of pavement resurfaced, and not to the cost per mile of the highways thus treated.

There were under maintenance during the past season 2,387 miles of bituminous macadam penetration method pavement, upon which the average expenditure, including resurfacing and reconstruction, was $510 per mile, and the average expenditure, exclusive of resurfacing and reconstruction, was $448 per mile. A much larger percentage of this type of macadam is located on the main trunk lines than that of the waterbound macadam and, in general, the motor vehicle traffic over this type is very much larger, in spite of which fact the maintenance is less than for the waterbound macadam pavement.

Of the bituminous macadam mixing method type, there were 63 miles under maintenance during the past season, upon which the average expenditure for maintenance was $181 per mile.

The expenditures on highways of this type during the past season have, in general, been for labor on the shoulders and gutters and other work outside of the pavement proper, although in a few instances it was necessary to do considerable patching to the pavement, but, in general, little or no repairs were required to the pavements.

The most unsatisfactory type of pavement, from the maintenance standpoint, is that of concrete bituminous type, and the construction of this type has been abandoned by our state.

The body of this pavement is formed of a low grade of cement concrete which was given a light surface treatment of bituminous material and fine stone chips at the time of construction. This thin surface treatment does not adhere to the concrete, is readily removed by traffic, which then wears into the concrete, necessitating frequent and constant patching. Numerous experiments have been tried out with surface treatment of varying depths, and the consensus of opinion of those who have endeavored to maintain this class of pavement is that any surfacing to be satisfactory must be thick enough to have stability in itself and not less than two inches in depth.

There were under maintenance during the past season 295 miles of this type of pavement, and the average expenditure, including new surfaces, was $1,050 per mile, and the average expenditure, exclusive of resurfacing, was $532 per mile.

There were under maintenance during the past season 84 miles of first-class concrete pavement, and the average expenditure on highways of this class was $129 per mile.

These pavements are of recent construction, the average age being one year, and the expenditures were nearly all for labor and materials on the shoulders and gutters, a small expenditure only being required on the pavement for filling the frost cracks with pitch.

From the limited experience in the maintenance of this type of pavement, it would seem that an expression in regard to the efficiency of the type should be reserved for at least another year.

Under the heading of "Block Pavement" have been grouped the expenditures for all brick, stone block and asphalt block pavements.

There were under maintenance during the past season 291 miles of these types of pavements, and there was an average expenditure on highways of this type of $190 per mile, including the reconstruction of one section about one-third of a mile in extent, and the expenditure for maintenance was $176 per mile.

This expenditure is, perhaps, about evenly divided between the pavement and the shoulders. The expense of the maintenance of the shoulders is much heavier with the rigid pavements, such as concrete and block, than with the macadam types. This is due to the smooth, rigid edge which catches and holds the traffic parallel thereto for short distances, similar to the effect of street car rails. A rut is soon formed along the edge of the pavement which is generally filled with crushed stone, increasing the cost of shoulder maintenance.

On the older brick pavements there has been expended a considerable amount during the past season for taking up and relaying small areas that have broken down. In the western section of the state, wherein is located the greatest mileage of brick pavement, some 102 miles, the average cost of maintenance of this type was $245 per mile.

Summarizing the mileage and the average expenditure for maintenance, repair and construction per mile per year for each of the different types, we have:

193 miles of gravel roads cost $955 per mile.
2,298 miles of waterbound macadam roads cost $1,055 per mile.
2,387 miles of bituminous macadam, penetration method roads cost $510 per mile.
63 miles of bituminous macadam, mixing method roads, cost $181 per mile.
295 miles of concrete bituminous roads cost $1,050 per mile.
84 miles of first-class concrete roads cost $129 per mile.
291 miles of block pavement roads cost $190 per mile.
5,611 miles of all types cost $750 per mile.

A review of the above summary would indicate that the various types could be grouped in three classes, namely, low, medium and high maintenance types, and when so grouped we have 438 miles of low maintenance type, including bituminous macadam, mixing method, first-class concrete and block pavement, upon which the average expenditure for maintenance was but $177 per mile per year; 2,387 miles of medium maintenance type, including bituminous macadam, penetration method, upon which the average expenditure was $510 per mile per year; 2,786 miles of high maintenance type, including gravel, waterbound macadam and concrete bituminous, upon which the average expenditure was $1,059 per mile per year.

If the low and medium maintenance types are grouped in one class, we have slightly over half the improved highways upon which the expenditure for maintenance is about $440 per mile per year, and slightly under one-half the total mileage upon which the expenditure for maintenance and repairs was $1,060 per mile per year.

It is contended that with the present system of maintenance in many cases the life of a pavement may be extended indefinitely. The method referred to is that of treating the surface of the pavement with a light application of asphaltic oil or refined tar, and a cover of fine crushed stone, sand or gravel. This treatment consists of spraying on the surface of the pavement about one-quarter of a gallon of oil or tar and covering the same with from ten to fifteen pounds of cover material per square yard of pavement. These materials are worked and kneaded into the existing pavement by the traffic, and most efficiently by rubber tire traffic, and results in filling up the small interstices between the larger fragments of the existing pavement and increasing the thickness of the pavement from an eighth to a quarter of an inch. This increase in thickness should more than offset the constant wearing away of the surface by the abrasion caused by the pounding of the iron-shod feet of the horses and the iron-tire vehicles. The repetition of this treatment from year to year will gradually increase the thickness of the existing pavement. The ideal condition being where this treatment approximately maintains the pavement at its original thickness, as it has been found that where the treatment has been too heavy or too frequently applied and the oil and stone mat is built up to a greater thickness than one-half inch, it is liable to creep and become displaced by traffic, particularly in hot weather.

The experience in our state would indicate that a waterbound macadam pavement under the average condition of rubber-tire traffic, should be treated once each year for two years, after construction, then perhaps the treatment may be omitted the third year, and in subsequent years treatment is required two years out of three.

With the penetration type of bituminous macadam, a surface treatment is not generally required until the second or third year after improvement, and thereafter a treatment every second or third year. The advantage of this type of treatment is the ability to thereby incorporate a thin layer of new material with the existing pavement at a minimum cost and restore, at more or less frequent intervals, the part which has been worn away by traffic.

The most efficient material seems to be one that carries 65 to 70 percentum of bitumen or pitch and which can be applied in a spray under pressure at a temperature of from 80 to 100 degrees F. This grade of material is sufficiently liquid for several days after being applied that it may be worked and kneaded into the porous surface of the pavement by the rubber-tire traffic.

A heavier material that requires heating to a temperature higher than 130 degrees F. in order that it may be applied, cools after application and before receiving traffic, and assumes a consistency of rubber gum, and while it may be united with the stone chips by rolling, it cannot be as thoroughly worked into the body of the pavement, and simply lies on the surface as a mat which shifts around under traffic and is worked into waves and hollows. An example of the principle is the painting and varnishing of wood surfaces. A thin paint or varnish is applied and is worked into the pores of the wood by brushing and rubbing and a more desirable and permanent surface is obtained than by using a heavier or thicker varnish applied by pouring the same on the wood surface. The varnish being so heavy it is necessary to heat the material to make it sufficiently liquid to be poured over the surface. No one would expect such a finish to a hard wood floor to be very desirable or lasting. The floor could be opened to use very much quicker, but permanent results could not be expected. This simile is set—an explanation for the necessity of the disagreeable condition of the road surface for a few days after the bituminous treatment is applied, during which period the traffic is working and kneading the more or less liquid material into the existing pavement.

There is also the necessity for the use of the light material in the subsequent treatments in that the light carrier oils soften the hardened material of the former treatments and allow new material to unite and combine therewith.

The best results are also obtained where the least amount of cover material permissible is used. This can best be explained by comparing the bituminous material to Portland cement when used with sand in mortar. A surplus of sand weakens the cementing qualities of the cement. The same results are obtained by using a surplus quantity of sand to cover the application sufficiently to eliminate the disagreeable condition of the freshly treated pavement. Where the pavement is not open, requiring a filler for the interstices, and where previous treatments have been given, better results will be obtained where no cover is used, but a freshly treated surface with no cover is dangerous to fast-moving vehicles and such treatment is seldom resorted to in the country districts.

While the best results with surface treatments are obtained with a semi-liquid bituminous product and a minimum amount of cover, the disagreeable features of this treatment from a traffic standpoint have been given serious consideration, and changes have been made in the specifications for surface treatments, which it is hoped will materially reduce the period during which the treated surface is objectionable from a traffic standpoint.

The light surface treatment with bituminous material and cover does not appear to be suited to pavements where horse-drawn, iron-tire traffic largely predominates. The iron-tire traffic appears to grind the bituminous material with the mineral aggregate and keep the surface roughened and loosened, allowing the volatile oils to more readily evaporate. The bituminous material then loses its adhesive qualities, and is ultimately ground to dust and is washed or blown away.

The bituminous mat tends to make the surface waterproof, and as the moisture in the macadam leaches away through the foundation and not being renewed from the surface the so-called waterbound macadam is no longer waterbound but is simply dustbound and is ready to be loosened by traffic in any spot where the bituminous surface mat is worn through, and it is necessary to either provide a heavy mat or constant patching of the areas where the mat has worn through. The tendency is therefore with the waterbound type to give a general treatment more often than should be necessary, which results in building up a heavy mat which finally creeps and displaces under traffic in hot weather, and it is then necessary to remove the entire mat and start over with the light surface treatments.

With the bituminous bound macadam this precaution is not as necessary. While the bituminous carpet sheds off the surface water and the macadam dries out, the individual fragments are bound together with a bituminous material and are not susceptible to the loosening effect of traffic as they are in the dried-out, waterbound type. The results being that a much thinner bituminous surface can be maintained without constant patching, which re-

sults in less frequent treatments being required, and the expense of maintenance of the surface by light bituminous treatments on bituminous bound macadam roads is not much over half of that for waterbound roads.

The bituminous macadam, however, being of a more plastic nature, is more easily displaced by swift-moving traffic, resulting in transverse waves developing in the body of the macadam, which are not as pleasing to ride over as the more rigid waterbound.

With reference to the cost figures submitted herewith, while they are the result of but one year's experience, it would seem that the large mileage represented would make the data of some value. This can be better appreciated when it is stated that the improved highways of New York, if laid down in a continuous line, would provide an improved highway from Boston to San Francisco, and from Maine to Florida, and thence to New Orleans.

With reference to the cost as expressed in units of miles, I would state that the standard width of pavement on our state and county highways is 16 feet, with earth shoulders of four to eight feet on each side of the pavement.

Referring to any statements which I have made which are contradictory to those of some of the other speakers, I wish to qualify my statements to the effect that they are simply the opinion of the speaker as gained by the observation of the maintenance of some 5,600 miles of improved highways.

As can readily be seen from the above data, the problem of maintenance has not as yet been mastered, but I believe, however, that the assembling in congress and conventions of this character, of men engaged in road work, where a free discussion of experience and ideas is permissible, will tend to and eventually be resultant in perfecting to a very large extent, the matter of road construction and the maintenance of same, and finally reducing it to a practical and economical basis.

The Jeffrey Manufacturing Co. have opened offices at Dallas, Texas, in the Commonwealth National Building. This office will be in charge of F. J. U. Jones.

Several bridges in the southern part of the province of Saskatchewan were damaged by the high water this spring. In one or two cases the bridges were entirely submerged so that the ice-flow passed over, but after the water had subsided it was found that the bridges had not been injured in any way.

The Dominion Government has decided to exclude all foreign lumber in connection with the public work carried on by it. At the present time the Parliament buildings at Ottawa are being rebuilt, but only Canadian lumber will go into the new structure. A short time ago the Canadian Pacific Railway issued a similar order. Both movements have been made for the purpose of encouraging the industry in the Dominion. Last year, although the country was at war, Canada imported 95,000,000 feet of southern pine, valued at over three million dollars. These figures were much below the previous year, but show something of the heavy importations of pine from the United States. Practically all our hardwood has been imported from south of the forty-ninth parallel, but according to the new arrangement, only Canadian hardwoods will be utilized in the public works of the Dominion. At the present time a number of important works are going on in addition to the rebuilding of the Parliament buildings, harbor improvements are being made at Montreal, Quebec, Toronto, and in connection with the Hudson Bay terminals. In these works Douglas fir will take the place of Southern pine, formerly used. For the interior decoration of cars and the wood used in their manufacture, Canadian woods will hereafter be used. It is said that the movement will spread and that big implement manufacturers will take it up.—*American Forestry.*

THE USE OF OIL ENGINES FOR PUMPING.*

By C. R. Knowles.

INTERNAL combustion engines using gasoline as fuel have long been in use for railway water service. The increased consumption of water, necessitating larger pumps and heavier power, together with the increase in the cost of gasoline, has made it necessary to look to a cheaper fuel in the operation of water stations.

In order to utilize the existing equipment many of the gasoline engines now in service have been converted to kerosene and distillate engines by the addition of attachments for preheating the oil to or near the flashing point before the oil enters the cylinder. These attachments consist of generators or mixing chambers wherein the oil is heated by the exhaust of the engine. They are made in various sizes and types, both for throttling and for hit and miss governors. With these attachments the engine is generally started on gasoline and is allowed to run on this fuel until the cylinder and generator are heated, when the oil is cut in. On other types a retort is provided where the oil is converted into a vapor or gas by heating the retort with a blow torch. Either method requires from five to ten minutes to start an engine running on oil. Electric ignition is used, as with gasoline engines. Very little carbon trouble is experienced with the use of these attachments and the lubrication required is about the same as with a gasoline engine.

A series of tests of various fuels were made pumping against a total head of 61 feet, with an 8 x 10-inch single cylinder double acting pump direct connected to a 6-h.p., four-cycle, horizontal gasoline engine equipped to run on kerosene and distillates as well as gasoline, controlled by a throttling governor. This engine was one of the first gasoline engines ever equipped to operate on low-grade oils and has been continually operated on distillates from 36° to 32° Baumé for the past six years.

The fuels used were:

TABLE I.

Distillate ...	40.0° Baumé	Flash, 150	Burn, 145
Methyl alcohol	40.5° Baumé	Flash and burn at room temp.	
Kerosene	46.0° Baumé	Flash, 124	Burn, 170
Gasoline	62.0° Baumé	Flash and burn at room temp.	
Motor spirits	58.0° Baumé	Flash and burn at room temp.	

Efficiency Fuel Tests.

	Distillate.	Alcohol.	Kerosene.	Gasoline.	Motor spirits.
Pints per hour	6.0	7.0	6.0	7.0	6.0
Pounds fuel per hour	5.145	6.062	4.943	5.373	4.755
Pounds of fuel per h.p.h. ..	1.91	2.22	1.91	1.97	1.74
Pump, r.p.m. ..	43.35	43.32	43.54	43.72	43.79
Pumped, gal. per min. ...	175.0	177.8	176.8	176.8	178.1
Cost of fuel per gal.	0.04625	0.40	0.08	0.15	0.13
Cost fuel per hour	0.0347	0.35	0.06	0.1313	0.0975
Cost of fuel per h.p.h.	0.0120	0.1282	0.0220	0.0483	0.0356
Cost per 1,000 gallons	0.0033	0.0327	0.0056	0.0124	0.0092
	Deg.	Deg.	Deg.	Deg.	Deg.
Temp. of cylinder start..	165	90	135	46	46
Temp. of cylinder run ..	145	145	145	130	125
Temp. of inlet air	110	125	120	60	60

As will be seen from the above figures the distillate is the most economical of the fuels used, the cost per water horse-power being 53 per cent. of the cost of pumping

*Presented at meeting of Illinois Section of the American Water Works Association.

with kerosene, and only 27 per cent. of the cost of pumping with gasoline. The high cost of alcohol eliminates it as a fuel for pumping water and the result of the test is merely submitted as a comparative feature. No doubt better results could have been obtained by reducing the area of the combustion chamber as more compression is required to secure economical results from the use of alcohol in internal combustion engines. The power obtained from the use of kerosene was practically the same as from the distillate, the only difference being in the price of the two fuels. The gasoline test shows such results as might be obtained from the average gasoline engine under the same conditions. The fuel known as motor spirits, which has been widely advertised as a substitute for gasoline, operates under practically the same conditions as gasoline. An objectionable feature of this oil is a disagreeable odor, and it would perhaps be undesirable to use in certain localities.

A 12-h.p., four-cycle gasoline engine with a hit and miss governor pulling a $7\frac{1}{2}$ x 30-inch working barrel in a deep well was equipped with a generator for burning low-grade oils. Comparative tests showed that the engine consumed the same amount of 39 degrees distillate per horse-power hour as gasoline. The difference in the cost of the two fuels, however, showing a saving of $.0434 per horse-power hour in the use of the distillate. The cost of pumping water at this point is comparatively high, due to the fact that the water is pumped with a single acting deep well cylinder.

The tabulated results obtained follow:

Table 2.

	Gasoline.	Distillate.
Pints per hour	14.0	14.0
Pounds of fuel per hour	11.746	12.005
Pounds fuel per h.p.h.	3.458	3.53
Pump, revolutions per minute	24.0	24.0
Pumped, gallons per minute	124.0	124.0
Cost fuel per gallon	0.125	0.04625
Cost of fuel per hour	21.875	8.093
Cost fuel per h.p.h.	0.0643	0.0209
Cost per 100 gallons water	0.0029	0.0108

The heavy oil engine is a comparatively recent development and is being extensively used in railway water stations, as well as for other service. The most popular engine of this type is the two-cycle oil engine constructed in units of 50 h.p. and under, using heavy oil as fuel. This type of engine is very often confused with high compression engines operating on the Diesel principle or with the converted gasoline engine using kerosene and distillates through a carburetor or mixing valve.

The cycle of operation of the Diesel engine is to compress air to 450 or 500 pounds per square inch, generating a temperature of approximately 540° C. Into this highly heated air the fuel is injected during the return or second stroke of the piston in a finely atomized form at such a rate as will maintain a constant temperature while burning and in such quantity as will do the required work for each stroke. The expanded gases of combustion are forced out of the cylinder during the third stroke, while the fourth stroke draws fresh air into the cylinder. This is the sequence of events in a four-cycle engine.

By expelling the burned gases with fresh air the necessary functions can be performed in two strokes of the piston, producing the so-called two-cycle engine.

The above-mentioned engine should not, however, be confused with the two-cycle oil engine as used in railway and other pumping stations and termed the Semi-Diesel engine. In order to avoid the high compression pressure and the resulting complication of design necessary in the Diesel engine this so-called Semi-Diesel engine has been devised, which does not compress the air sufficiently to raise the temperature to such a point that it will spontaneously ignite the injected fuel. It is this type of engine which we have to deal with, particularly with the two-cycle, valveless injection engine, in which the compression has been reduced, adding the required temperature in a heated combustion chamber. This engine is governed by throttling the oil supply and ignition is accomplished by means of a hollow ball. This ball is heated by a blow torch before starting, but after the engine is running the heat is maintained by the successive explosions. The fuel is introduced through fuel valves similar to the Diesel engine, but much less compression of air is required, the compression of the Semi-Diesel engines being from 80 to 130 pounds. Crank case compression is $1\frac{3}{4}$ to $3\frac{1}{2}$ pounds.

Although these engines have a theoretically less efficient heat cycle than the Diesel they gain in simplicity of construction.

Intelligent lubrication is essential to the proper operation of the oil engine. Improper lubrication contributes largely to oil engine trouble. The high speeds and temperature at which these engines work necessitate a continuous and skilful use of good oil. A great deal depends upon the proper lubrication of an engine of this type and the prevention of the carbon forming in the cylinder. The destruction of the lubricating oil by combustion cannot be prevented. Just what occurs to the oil in an internal combustion engine cannot be entirely explained, but there is no doubt that a great deal of it is burned along with the fuel oil and as long as this is true it is necessary that complete combustion takes place, in order that a residue of unburnt oil is not left in the cylinder in the form of carbon.

The lubrication of the steam engine or pump is comparatively simple. In steam engines there is a certain amount of moisture to assist lubrication, but the flames of an oil engine dry the internal surfaces and unless the proper amount of oil is applied, the cylinder, piston and rings soon begin to suffer. In a steam engine or pump the temperature will at the most reach about 500 degrees while in an oil engine it rises to as high as 2,500 degrees. Added to this is the fact that the piston speed of an internal combustion engine is from three to four times that of a steam engine or pump. Consequently the oil engine requires a different method of lubrication and a great deal more of it.

Engines of this type are liable to suffer from carbon trouble and resultant deterioration due to the fact that an excess of oil injected into the cylinder breaks up into volatile compounds, such as the naphthas, heavy tar-like oils and free carbon.

Overloading the engine also will cause carbon trouble. When the engine is working up to its maximum power, a momentary overload will cause an excess of oil, and the resultant accumulation of carbon due to the fact that the oil engine is not flexible enough to adjust itself instantly to the varying loads, as does a steam engine or pump.

The carbon troubles may be reduced to the minimum by the use of the proper oil. Fuel oils vary in quality as do hard and soft coal and even to a greater extent. As a result, some oils are better suited for use in oil engines than others. While it is possible to burn almost any oil that will flow freely, the best results are to be obtained from oils of a paraffin base from 30° to 36° Baumé.

A number of tests were conducted on a 25-h.p. oil engine with a 10 x 14-inch cylinder belted to a 10 x 12-inch duplex power pump, using seven different kinds of oil, ranging from a heavy fuel oil of an asphalt base to a

light distillate of a paraffin base. A brief description of the oils used follows:

No. 1. Diesel fuel oil, 26° Baumé, made from asphaltum base crudes from Texas and Louisiana fields.

No. 2. Gulf fuel oil, 24° Baumé, made from asphaltum base crudes from Oklahoma fields.

No. 3. Narico distillate, 39° Baumé, made from semi-paraffin base mid-continent crudes.

No. 4. Motor oil, 42° Baumé, made from paraffin base crudes from Cushing Oklahoma fields.

No. 5. Navy fuel oil, 26° Baumé, made from asphaltum base crudes from Texas and Oklahoma fields.

No. 6. No. 1 fuel oil, 32° Baumé, a non-sulphur oil paraffin base from Illinois crudes.

No. 7. Kentucky crude oil, 32.5° Baumé, paraffin base.

The following table gives the results obtained from the use of the above oils. The costs given cover the fuel only:

TABLE 3.

	1	2	3	4	5	6	7
Gallons of oil used per hour	1.51	2.29	2.04	1 88	2 19	2 00	2 10
Pounds of oil used per hour	11.30	17.33	14 07	12.20	16.38	14.40	15 07
Pounds of oil used per w.h.p.	1.02	1.12	0.98	0.80	1.01	0.96	0.85
Engine r.p.m. ...	346.0	337.0	345.0	345 0	342.0	338.0	328.0
Pump r.p.m. ...	40 0	39.0	40 0	40.0	40 0	39.0	38.0
Gallons pumped per minute ..	444.0	603.0	583 0	592.0	586.0	580 0	577.0
Cost of oil per gallon ...	0.029	0.029	0 031	0.03	0.029	0.025	0.016
Cost of oil per hour......	0 044	0 066	0.063	0.056	0.063	0.05	0 035
Cost per 1000 gallons... ...	0.0016	0.0019	0.0022	0.0016	0.0018	0.0015	0.0009

While these tests are not conclusive, they indicate the wide range of fuels it is possible to burn in these engines.

The following tables give the result of tests conducted in pumping with 4-inch centrifugal pumps using two-cycle Semi-Diesel oil engines for power, one pump being driven by a 25-h.p. horizontal engine and the other by a 25-h.p. vertical engine, both pumps being belt-driven.

Table 4 gives the result of one hour's run, while Table 5 gives the hours run and cost for a period of four months for each engine.

Tables 6 and 7 show the results obtained in pumping with a 25-h.p., horizontal, two-cycle, heavy-oil engine belted to a 10 x 12-inch double acting duplex power pump and a 30-h.p. vertical two-cycle heavy-oil engine belted to a 11 x 12-inch single acting triplex power pump.

TABLE 4.

Test One Hour's Run.

	Horizontal engine.	Vertical engine.
R.p.m. engine	315.0	380.0
R.p.m. pump	1587.0	1320.0
Gallons pumped per minute	571.0	571.0
Total head in feet	77.38	79.69
Fuel oil consumed in gallons	2.25	2.65
Water horse power	11.15	11.5
Brake horse power	21.4	22.1
Cost fuel oil per million gallons ..	$1.67	$1.97
Cost of fuel oil per gallon	0.0253	0.0253
Cost per h.p.h.	0.0026	0.0030

TABLE 5.

Cost of Fuel and Lubricants Four Months' Run each Engine.

	Horizontal engine.	Vertical engine.
Total number of hours run	331	316
Gallons water pumped	9,930,000	9,480,000
Cost of kerosene	$ 3.78	$ 1.50
Cost of fuel oil	18.01	18.47
Cost of lubricants	9.20	10.20
	$30.99	$30.17
Cost per 1,000,000 gallons	3.12	3.18

TABLE 6.

Test One Hour's Run.

	Duplex pump horizontal engine.	Triplex pump vertical engine.
R.p.m. engine	342	396
R.p.m. pump	40	44
Gallons pumped per minute	586	640
Total head in feet	104	100
Fuel oil consumed in gallons	2.19	2.70
Water horse power	15.33	17.5
Brake horse power	20.44	23.33
Cost fuel oil per millions gallons pumped	$1.80	$2.00
Cost fuel oil per gallon	0.029	0.029
Cost per h.p.h.	0.0031	0.033

TABLE 7.

Cost of Fuel and Lubricants Four Months' Fun each Engine.

	Duplex pump horizontal engine.	Triplex pump vertical engine.
Total number of hours run	687	677
Gallons water pumped	24,732,000	24,372,000
Cost of kerosene	$ 8.52	$ 9.78
Cost of fuel oil	26.26	31.37
Cost of lubricants	17.10	22.04
Total cost	51.88	63.19
Cost per million gallons	$ 2.09	$ 2.54

Table 6 giving the results for one hour's run and Table 7 cost for a period of four months for each engine.

Although the oil engine cannot yet be considered as fully developed, it has passed the experimental stage, and while it is, perhaps, not as reliable under all conditions as a steam engine or pump, much of the prejudice against the oil engine is undoubtedly due to lack of experience in handling. With the present imperfect knowledge of what the engine is capable of doing and of what particular oils may be burned in it, one cannot speak conclusively, but there is no doubt that the future of the engine is assured.

INCREASING MINERAL OUTPUT.

The war has given a marked stimulus to the demand for Canadian minerals. The returns of mineral production, as tabulated by the Ontario bureau of mines, during the first three months of 1916 show increases in that province in all products with the exception of iron ore. The Ontario figures are typical of activity in all our mining districts. They are taken as an example, being the most up-to-date returns, a matter upon which the Ontario bureau of mines is to be complimented. The value of the production in the province for the first three months of 1916 was $14,276,382 as compared with $9,358,210 for the corresponding period of last year. This large increase was due not only to the greater output but to the higher prices now prevailing for most of the metals.

There was an increase of 31,511 ounces in the yield of gold, a gain worth $656,000. The porcupine camp provided the bulk of the production for the quarter, namely, 99,282 ounces. The prospects are for considerable development in that camp. An increase occurred in the production of silver as compared with the first three months of 1915 and the value of the product was greater, due to the rise in the price of silver. The benefit of the higher price will be felt still more in the Cobalt camp during the second quarter of the year. The output at the Sudbury mines of nickel and copper in the matte was 50 per cent. greater than for the corresponding period of 1915. The blast furnaces of Ontario produced 70 per cent. more pig iron than they did in the first quarter of 1915 and the product was worth 100 per cent. more.

Greater mineral production is having a favorable effect upon the trade statistics. Exports of minerals for the fiscal year 1914 totalled $59,000,000. In 1915, they dropped to $51,740,000 but for the twelve months ended March 31st, 1916, they amounted to $66,580,000.

TEMPERATURE STRESSES IN A SERIES OF CONCRETE GIRDER SPANS UNDER DIFFERENT CONDITIONS OF END SUPPORT.*

THE following summary of the results of an investigation made to determine the most favorable arrangement, to resist temperature stresses, of a series of concrete girder spans supported on concrete piers, is of interest and value. In our summary we have omitted the derivation of general formulas:

The investigation was made in connection with the design of a viaduct over the tracks of the St. Louis, Iron Mountain & Southern Railroad at Little Rock, Arkansas. The design finally agreed upon consists of a series of six simple girder spans, the outer girders of which have somewhat the appearance of arches. The three east spans are each composed of eight steel girders covered and decked with reinforced concrete, while the three west spans are each composed of eight reinforced concrete girders with an integral reinforced concrete deck. All spans are supported on solid concrete piers, 3 ft. wide at the coping. Although the piers are similar in design they have different angles of skew, and therefore different degrees of stiffness in the line of the viaduct. The concrete spans, which alone will be considered here, are approximately of constant section except as to the amount of reinforcement.

pendicular to the axis of the bridge are given in Table I. The heights of the piers (shown in Fig. 1) are in each case given from the base to the neutral plane of the spans. Although these heights vary somewhat they are assumed equal in the investigation.

The problem arose from the proposal to build the three concrete spans integral with the piers and abutments, *i.e.*, without provision for changes in length due to temperature and shrinkage. It is evident that the piers offer resistance to the free expansion or contraction of the spans which they support, and hence must introduce corresponding stresses. If these stresses are not negligible, and if expansion must be provided for, the problem is to determine how many expansion joints are necessary, and where they should be placed.

The results summarized in Table II. were obtained for a change of 40° F. by the method of least work and the Castigliano theorem for one, two, and three spans of variable stiffness and inelastic abutments, the following cases being considered:

Case II. The three concrete spans monolithic, supported without friction on piers 3 and 4 and fixed with frictionless pins on pier 5 and the west abutment. (See Fig. 1.)

Case III. Spans supported without friction on the abutment and pier 3 and fixed on piers 4 and 5.

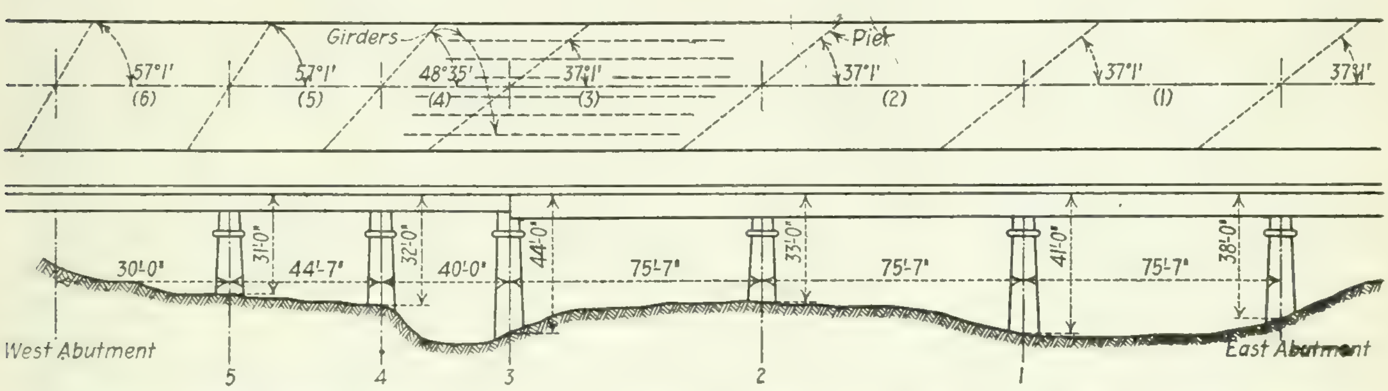


Fig. 1.—Sketch Showing General Features of Design of Viaduct Over Tracks of St. Louis, Iron Mountain & Southern Railroad at Little Rock, Ark.

Fig. 1 shows diagrammatically the general conditions of design. The outer or sidewalk girders of the concrete spans are continuous over the two intermediate piers; the other six girders of each span are not. The areas of steel and concrete in the several spans and the respective average moments of inertia of the piers about axes per-

Table I.—Data on Concrete Spans and Piers.

Girder span.	*Area, sq. ins.	Average span, ins.	Pier.	Assumed height, ins.	†Moment of inertia, I.	Width, ins.
6 ..	14,300	600	5	480	509,201,000	230
5 ..	13,960	530	4	480	752,342,100	275
4 ..	13,960	480	3	480	1,090,534,000	327

*Including steel in terms of concrete.

†$I = IA \sin^2 L + IB \cos^2 L$, in which L = angle between axis of pier and axis of I (perpendicular to viaduct axis), IA = moment of inertia of pier about its short axis, and IB = moment of inertia about its long axis.

E = 3,000,000; temperature range, 40° F.; coefficient of expansion, 0.0000055.

*Summary of paper by Tresham D. Gregg, in Proceedings, American Society of Civil Engineers, Vol. XLII., p. 213.

Case IV. Spans supported without friction on pier 3 and fixed on piers 4 and 5 and on the abutment.

Case V. Spans supported without friction on the abutment and fixed on piers 3, 4 and 5.

Case VI. Spans fixed on all four supports.

By referring to Table II. it will be noted that there are given the average unit stress in each of the three spans and the unit bending stress in each pier for each of the five cases assumed.

The arrangement for Case VI. causes severe stresses in all three spans and in piers 3 and 4. In the spans the stresses are increased from 72 to 92 per cent. of the allowable, and the bending stresses caused in the piers are from 21 to 143 per cent. of the allowable, assuming the piers to be of 600-lb. concrete. It will be noted that the stresses in the spans decrease as those in the piers increase.

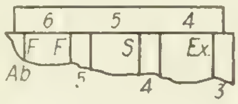
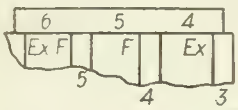
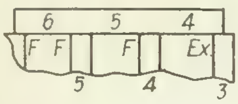
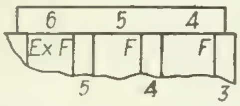
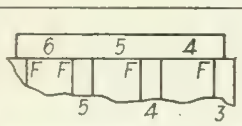
For Case IV., with an expansion joint at pier 3, the temperature stresses in span 4 and in pier 3 are reduced to zero; those in spans 5 and 6 are reduced; and the bending stresses in piers 4 and 5, lacking the strong support of pier 3, are increased, pier 4 being stressed to 182 per cent. of the allowable.

If, instead of placing a joint at pier 3, we place one at the abutment, as in Case V., the stresses in the spans are still further decreased, as are the bending stresses in piers 3 and 4. Pier 5, however, takes a heavy increase in stress to 126 per cent. of the allowable unit concrete stress.

Now, if we place expansion joints at both the abutment and at pier 3, as in Case III., we have the most favorable of the five cases considered. The stress in span 5 is only 27 per cent. of the allowable, but the stresses in the piers are 65 and 80 per cent. of the allowable; they can be neglected, however, as the direct stress is small.

For Case II. the stress in span 6 is 40 per cent. and in span 5, 125 per cent. of the allowable unit stress.

Table II.—Average Unit Stresses in Spans and Unit Bending Stresses in Piers for Various Assumed Conditions.

Case	Condition of ends of spans	Average unit stress in spans, lb.			Unit bending stress in piers, lb.		
		6	5	4	5	4	3
II		240	0	0	750	0	0
III		0	160	0	480	390	0
IV		480	400	0	145	1,090	0
V		0	250	300	755	115	600
VI		590	560	430	125	490	860

NOTE: Ex. = expansion joint; F = fixed on pier; S = sliding on pier.

The foregoing stresses will, of course, be modified somewhat by the fact that there actually will be considerable resistance at the expansion joints, due to friction.

The problem is now resolved into one of determining the relative economy of expansion joints and of reducing the maximum live and dead load unit stresses by increasing the section. Case III. is the only arrangement with a restrained span which would not produce prohibitive stresses in at least one of the piers. It should be noted that increasing the section of span 5 will increase the stresses in piers 4 and 5 in direct proportion.

The plan finally adopted was to place expansion joints at the abutment and at pier 3 and a sliding joint over pier 5. The steel-encased spans in the east half of the viaduct are all provided with expansion joints.

Those responsible for the design of this viaduct were I. L. Simmons and C. E. Smith, bridge engineers, respectively, of the Chicago, Rock Island & Pacific and the St. Louis, Iron Mountain and Southern Railroads.

RESULTS OF FIRST YEAR'S EXPERIMENTS WITH SMALL SEWAGE TREATMENT PLANTS BY U.S. PUBLIC HEALTH SERVICE.*

By Leslie C. Frank,
Sanitary Engineer, U.S. Public Health Service, Washington, D.C.

IN attacking the problem of small-scale sewage treatment it is desirable to emphasize strongly the fact that the experiments by the very nature of the problem, should be prolonged. Most sewage treatment devices show seasonal variations and the result of one season's experimental work has about the same significance as a single laboratory experiment. It is by no means true, for example, that a sand filter which gives certain results under given conditions of operation one year may be expected to give the same results under the same conditions the next year. Accumulation phenomena, such as the gradual clogging of the pores of the sand, may occur and cause entirely different results the second or later years of operation. The following discussion of some of the first year's Public Health Service experiments is therefore very tentative, and no hesitation will be felt in subsequent progress reports in modifying any statement here made.

The devices that are being or will be subjected to experiment during these investigations are: Imhoff tank, biolytic tank, sand bed, contact bed, sprinkling filter, and automatic disinfection apparatus. Generally, more than one of the above devices will be used in combination. The combinations which seem most promising are being studied first. Only one combination is discussed here, that of the Imhoff tank and sand bed, as it is not considered that the other investigations have proceeded sufficiently far to merit any discussion.

Sources of Sewage Tested.—Sewage was tested from two sources. The sewage subjected to the most careful test was that coming from about 25 people comprising a nurses' dormitory and one residence. The sewage flow was about 100 gal. per capita daily. The occasional samples of raw sewage gave an average value somewhat over 1,000 parts per million total solids and 177 p.p.m., for 24-hour 20° C., oxygen demand. The other sewage used for testing was that from about 60 people in a small community in Chevy Chase, Md. The latter plant is being used merely as supplementary to the more important Hygienic Laboratory Testing Station.

Design of Experimental Imhoff Tank.—It was not considered certain that an Imhoff tank would be adaptable to small plants, for the small-plant sewage would generally be stronger, certain more grease, and its flow be more irregular. It was feared that the presence of large quantities of grease might result in scum difficulties in the first compartment of the settling chamber, and that the very low night flow might result in the sewage becoming septic. In addition, the depth of the small tank would, for economic reasons, probably have to be limited to about 10 or 12 ft., whereas large tanks are generally 20 ft. or more in depth, and the depth of the tank is considered by many authorities to have an important effect on the quality of the digested sludge.

In designing the experimental Imhoff tank the following points were considered: Volume and proportions of settling chamber, inclination of partition walls, scum boards, clearance and overlap of slot, treatment of grease, volume of sludge chamber.

*From a paper read before the New Jersey Sanitary Association.

Volume of Settling Chamber.—The volume of the settling chamber determines the detention period. If the detention period be made too short, the settleable solids will be incompletely removed, and if too long, the sewage will become septic. In the United States the settling chamber for large Imhoff tanks is usually made equivalent to 1/9 the daily flow, which is equivalent to a mean detention period of 2.6 hours. It was not considered advisable to design the settling chamber for a small tank on this basis on account of the wider variations of flow. It was estimated that the variations in flow might be properly allowed for by assuming the daily flow to take place in 12 hours and by giving a detention period on this basis of three hours; in other words, by making the settling chamber equal in volume to one-quarter the daily flow, which is equivalent to a mean detention period of 6 hours instead of 2.6 hours, as in the large plants. It was decided to risk the possible danger of making the effluent septic.

Relative Proportions of Settling Chamber.—The volume of the settling chamber is not alone responsible for the degree of removal of settleable solids. The chamber must neither be made so short and wide as to result in short-circuiting through local currents, nor so long and narrow as to approach the proportions of a channel, in which case swirling velocities will occur and hinder sedimentation. The proportions selected must depend largely upon experience, and while considerable experience is available for large plants, this is not so true of small plants. However, the dimensions of the experimental tanks were arbitrarily placed within the range of large-scale experience. The proportions of length, width, and depth were for the Hygienic Laboratory tank 8 : 3 : 5, and for the Chevy Chase tank, 11 : 1.7 : 3.

Inclination of Partition Walls.—The inclination of the partition walls separating the settling chamber from the sludge chamber was made 2.6 vertical to 1 horizontal in the Hygienic Laboratory tank and 1.5 : 1 in the Chevy Chase tank. In small plants steepness of partition walls is even more important than in large plants, because in the latter the attendant may generally be relied upon to squeegee the inner surfaces if the accumulated sludge refuses to slide properly towards the slot, whereas in the former no such attendance can be expected. It was for this reason that it was decided to try different inclinations.

Slot Clearance and Overlap.—In large tanks the clearance of the communicating slot is generally made from 6 to 8 ins., while the overlap is generally made about 8 ins. This becomes a very serious matter for small plants. With a partition inclination of 1.5 : 1 an 8-in. slot clearance and an 8-in. overlap mean roughly about 2 ft. 3 in. vertical distance between the lower edges of the two partitions, which is a considerable proportion of a total depth of 10 or 12 ft., and deducts that much from the sludge capacity. It was decided to reduce the slot clearance arbitrarily to 5 ins. and the slot overlap to 6 ins. There is some question whether a small tank really needs so large a slot clearance, as it seems likely that the slot cloggings which occur in Imhoff tanks are often caused by the fact that the passage of settled sludge through the slot is not continuous, but intermittent. The sludge particles may be conceived as accumulating upon the inclined surfaces until the sliding thickness is reached, when the mass will begin to slide and pass rather suddenly towards the slot, perhaps developing one or more folds in the region of the slot. The clearance of the slot must be sufficient to pass these sliding sheets. The thickness of these sliding sheets and the extent to which they will fold upon themselves will depend upon the inclination and length of the surfaces upon which they develop. Since the length of these inclined surfaces will naturally be less as the size of the tank diminishes, it seems logical to reduce the slot clearance accordingly.

Grease Chamber.—On account of the tendency of grease in fresh sewage to mix with fecal and other solid matters, and to cause the whole mass to float and become sufficiently dry to prevent decomposition, it was decided to place a horizontal screen at the water level in the first compartment of the settling chamber. This would keep the floating solids submerged, and allow them to become waterlogged and sink to the bottom. The mixing caused by the incoming sewage would also tend to separate the grease from the other solids. The introduction of this horizontal screen has apparently been successful. There have never been more than 2 ins. of grease under the screen in the Chevy Chase tank and at the Hygienic Laboratory the material which has collected, while more voluminous, has been found to be almost pure grease, the removal of which was not at all objectionable.

Gas Vents.—Gas vents were provided on either side of the settling chambers. At the Hygienic Laboratory their total area is 8 sq. ft. and at Chevy Chase 40 sq. ft.

Sludge Capacity and Depth of Tanks.—Sludge capacity was provided for about 2 cu. ft. per person at the Hygienic Laboratory tank and 4 cu. ft. at the Chevy Chase tank. After providing the necessary settling chamber and sludge room capacities the total depth of the Imhoff tank at the Hygienic Laboratory was 10 ft., and at Chevy Chase 12 ft.

Sludge Removal and Disposal.—No permanent sludge pipe was included in the experimental tanks. Instead it was decided that when sludge was to be removed an ordinary bilge or trench pump would be used. No special provision was made for the disposal of the sludge, for the possibility was anticipated that for most small plants shallow trench disposal could be used. A relatively small area would be required.

Scum Boards.—One scum board was provided at the influent end and one at the effluent end of the settling chamber. The penetration below minimum water level of the first scum board was made 3 ft. because it was to serve also as one wall of the grease chamber. The penetration of the effluent scum board was made 2 ft., which was later found to be excessive.

Covers.—The tanks were provided with covers as a safety feature, as a possible preventive of odors, and to keep the grease and scum from drying.

Sand Bed and Dosing Chamber: Function.—The function of the sand bed is to satisfy as much as possible of the oxygen demand of the non-settleable organic substances in the sewage, and thereby to deliver an effluent which will not cause nuisance and which will remove part of the burden of possible water purification plants. The function of the dosing chamber is to control the manner of the application of the settled sewage upon the sand bed in such a way as best to promote the activity of the oxidizing organisms.

General Description.—The experimental sand bed as designed for the Hygienic Laboratory plant consisted of a layer of sand 2 ft. deep and 7 x 12 ft. in area, resting upon a drainage layer of gravel 6 ins. deep. The effective size of the sand was 0.24 mm. The dosing chamber was 3 ft. in diameter and contained a 3-in. Miller sewage siphon of 15-in. draw. Each dose from the dosing chamber discharged a layer of sewage upon the sand bed about 0.1 ft. in depth.

Experimental Results.

Imhoff Tank. Removal of Settleable Solids.—The average total solids in the raw sewage applied to the Hygienic Laboratory Imhoff tank for three months was 1,000 p.p.m. For the same period the average total solids in the tank effluent were 330 p.p.m. The total solids settled out by the tank were therefore 670 p.p.m. The average settleable solids in the tank effluent were 14 p.p.m. Hence the total settleable solids in the raw sewage were 684 p.p.m. and 98 per cent. of the settleable solids were therefore removed by the tank.

Volume of Sludge per Person.—The experimental tanks have not been operated for a sufficient length of time to justify definite conclusions as to the volume of sludge received. Our records to date indicate a probable rate of 2.6 cu. ft. per person per year at one plant and 4 cu. ft. at the other. This indicates a possible range of variation which may be expected in small tanks, apparently similar.

Condition of the Sludge.—The digested sludge is black in color, has the characteristic Imhoff sludge odor, streaks very quickly in a porcelain dish, showing that it has lost its stickiness and waterholding power, but has a relatively high moisture content, generally about 95 per cent. It is probable that the high moisture content is due to the shallowness of the sludge layer. Sufficient sludge has not accumulated as yet to justify drying experiments. Its appearance, however, indicates that there will probably be no difficulty in doing this without nuisance.

Freshness of Effluent.—The mean detention period in the Hygienic Laboratory tank is about five hours instead of six hours, as the flow has been somewhat higher than was expected. At Chevy Chase it is about six hours. These are higher values than those employed in large tanks, but the effluent has practically never been septic and has had at all times the odor of fresh sewage. It seems likely, therefore, that where sewage is settled so close to the source as is usually the case with small tanks, a mean detention of five or six hours will not render it septic or foul-smelling.

Scum and Foaming.—Both heavy scum formation and foaming occurred in the operation of the tanks. The most significant run on the Hygienic Laboratory tank began on November 19, 1914. Scum commenced to form almost immediately in the side vents and apparently continued increasing in thickness until July 5, 1915, with relatively little sludge being deposited in the sludge chamber. The scum was yellowish-gray, except the top quarter inch, which was black. Unless the scum was stirred no odor could be perceived outside the tank, even if the covers were removed. Upon spading or stirring, however, a distinct fecal odor could be noticed. At this time a sudden change took place and nearly all of the yellowish-gray scum changed to gray foam and began to boil over the top of the tank. Spading the scum caused it to deflate and collapse, but it soon became necessary to spade the scum twice a day in order to prevent it from foaming over. Finally, on July 13 and 14, some of the foam was removed and buried, in amount about 21 cu. ft., or somewhat less than 1 cu. ft. per person. It was impossible to determine what proportion this was of the total scum and foam present. From then until now, four months later, no further foaming has been observed. The scum is now entirely different, consisting mostly of seeds, grease, bits of cloth, and other not easily decomposable substances. It cannot be said, therefore, that difficulties with scum and foaming have occurred to a serious degree, since the foaming-over period at the Hygienic Laboratory lasted only about 10 days, and this could probably have been prevented by an earlier removal of the scum or by the provision of larger gas vents.

Sand Bed.—As above stated, the sand bed design intended a sand depth of 2 ft., but on account of compacting the depth decreased to 18 ins. after a few doses had been applied. The results, however, were so good that it was decided not to increase the depth, but to determine the purifying power of 18 ins. The rate of dosing was about 200,000 gal. per acre per day. For the month of October, 1914, the average dissolved oxygen present in the effluent was 5.4 p.p.m., the average 24-hour 20° C. oxygen demand was 2.2 p.p.m. and the relative stability over 90 per cent., corresponding to a time of decolorization of methylene blue of over 10 days. During the following winter much difficulty was experienced with the sand bed and frequent rakings and spadings were necessary. The bed was provided with tongue-and-groove covers, and while these prevented the formation of ice the frequent clogging did not diminish. More attention had to be given than can be reasonably relied upon for small plants. For some reason the depth of sand decreased during the winter and spring to about 15 ins. It seems probable that the frequent deep spadings caused some of the sand to pass down into the gravel layer. From November, 1914, to May, 1915, the average dissolved oxygen was 5.7 p.p.m., and the average oxygen demand 14.4 p.p.m. This included a period from April 7 to 30 when the dissolved oxygen was 2.6 p.p.m. and the average oxygen demand was 33.8 p.p.m. On May 15 green growths appeared quite copiously on the sand surface and continued forming until June 19. Several rakings were necessary during this time. From June 19 until October 4 no further rakings were necessary, and during this time weeds grew in abundance on the bed, but did not visibly increase the time of passage of a dose, which was generally about 15 to 20 minutes. Occasionally there seemed to be some evidence that short-circuiting was taking place through the 15-in. sand layer, but we were not able to establish direct evidence of this at any time. During the three months of July, August and September of the past summer, the net rate of dosage was 190,000 gal. per acre per day, the influent had no dissolved oxygen, demand, and no nitrates, while the effluent contained 2.2 p.p.m. dissolved oxygen, 12 p.p.m. of oxygen demand and 8 p.p.m. of nitrates.

Conclusions.—Our experience thus far justifies the following tentative conclusions:

(1) It is possible by means of a five-hour mean detention period in a properly designed Imhoff tank to remove from the raw sewage of small communities 98 per cent. of the settleable solids without producing a nuisance.

(2) A mean detention period of six hours, based on the average daily flow, will not cause the sewage to become septic or foul-smelling if it is fresh when it enters the tank.

(3) The accumulation of a disagreeable mass of grease and fecal matters in the first compartment of the settling chamber may be prevented by the introduction of a horizontal coarse mesh screen at the water level of this chamber. The screen keeps the floating matters submerged and apparently results in all fecal matter sooner or later becoming waterlogged and sinking through the slot into the sludge chamber.

(4) It is too soon to state with conviction the amount of digested sludge that may be expected from small-scale tanks, but one tank indicates an apparent accumulation of 2.6 cu. ft. per year per person and another tank 4 cu. ft.

(5) The only period during which the Imhoff tanks required daily attention was the foaming period, which

lasted about 10 days, and during which time some of the foam had to be removed and buried. At all other times attention once a month at the most was ample.

(6) Since the foaming period has been passed the scum formation has been slight.

(7) The decomposed sludge obtained from the small-scale Imhoff tanks resembled that obtained in large tanks except that it had a much higher moisture content. This may perhaps be explained by the shallowness of the sludge layer.

(8) A 15-in. sand bed dosed with settled sewage at a net rate of 190,000 gal. per acre per day during the second summer reduced an average oxygen demand of 63 p.p.m. to 12 p.p.m. (24-hour 20° C.). This is probably ample purification for many cases, but insufficient for others.

(9) The sand bed required very little attention during the summer months, but what would seem to be a prohibitive amount of attention during the winter months, even though covered with a tongue-and-groove wooden cover.

(10) No nuisance was produced during the summer months by the dosing of the uncovered sand bed with the Imhoff tank effluent.

(11) The growth of weeds on the sand surface did not seem to have an unfavorable effect upon the operation of the sand bed.

In General.—The foregoing work has indicated the desirability of continuing the experiments upon Imhoff tanks in order to confirm the past satisfactory results, and the desirability of continuing the experiments upon sand beds in order to improve only fairly satisfactory results. Further experiments will be made upon deeper sand beds at lower rates of dosing.

The work has been done under the general direction of Prof. Earle B. Phelps. The analytical work was done by Sanitary Bacteriologist H. L. Shoub. The writer, with Sanitary Bacteriologist C. P. Rhynus as assistant, was in immediate charge.

The Canadian Railway Club, Inc., Montreal, has elected the following officers for the season 1916-17: President, R. M. Hannaford, Assist. Chief Engineer, Montreal Tramways Co., Montreal; 1st vice-president, G. E. Smart, Canadian Government Railways, Moncton, N.B.; 2nd vice-president, Prof. Keay, McGill University, Montreal; secretary, Jas. Powell, Chief Draughtsman, G.T.R., Montreal; treasurer, W. H. Stewart, Imperial Munitions Board, Ottawa; executive committee, T. C. Hudson, Master Mechanic, C.N.Q. Railway, Joliette, Que.; E. E. Lloyd, C.P.R., Montreal; J. Hendry, Master Car Builder, G.T.R., Montreal; C. Manning, Secretary to Superintendent of Motive Power, G.T.R., Montreal; C. W. Van Buren, General Master Car Builder, C.P.R., Montreal; and W. H. Winterrowd, Assist. to Chief Mechanical Engineer, C.P.R., Montreal.

The largest combination of weight and size ever handled on one freight car by an American railway has been started on a journey to Joplin, Mo., from the yards of the Pennsylvania road at Greenville, N.J. This record-breaking load consisted of the generator for an 8,000 kilowatt turbine, purchased by Henry L. Doherty & Co. from the Brooklyn Edison Company. The generator is in one piece, weighs 160,000 pounds, and as measured by the railroad from the surface of the rails to the top of the machine stands 15 feet 7½ inches in height. Because of this extreme height the railroad was forced to lay out a special itinerary of detouring so that no tunnels or other possible clearance obstacles would be encountered on the run from New York to St. Louis. It is thought St. Louis will be reached in about six weeks, and then another journey must be taken to Joplin, where the generator will be installed at the plant of the Empire District Electric Company, a subsidiary of Cities Service Company.

TREATED WOOD BLOCK FLOORING.*

By C. H. Teesdale,
Asst. Engineer, Forest Products Laboratory, Madison, Wis.

SINCE 1900 there has been a steady and rapid increase in the use of creosoted wood blocks for paving the streets of our cities. A more recent development has been their adoption for a variety of uses other than street paving. Those qualities which make the wood block desirable for street work should also make it desirable for flooring where heavy trucking, the moving of heavy machinery, etc., make the maintenance of floors a serious problem.

Letters were written to those plants manufacturing creosoted wood blocks requesting data on their methods of manufacturing and construction. Not many of the treating plants have as yet produced very much of this product. Reports were received from 13 commercial plants and one railroad plant.

Eleven of the plants reported the use of southern yellow or longleaf pine. Five plants also recommended eastern tamarack as being satisfactory, and the three western plants recommended Douglas fir; black gum, beech, Norway pine, maple, hemlock, and western larch were recommended by one plant each.

Several of the plants, particularly those producing the largest quantity of this material, pointed out that the wood block flooring problem naturally divides itself into two classes:—

(*a*) Blocks used in very dry situations, as in factories and warehouses.

(*b*) Those used in alternately wet and dry, or in wet situations, as in stable floors, docks, wharves, slaughter houses, etc., where the blocks are exposed to the weather, to flushing with water, etc.

The treatment and method of handling the blocks differs radically in the two cases. Eight of the 13 plants reported in favor of using a distillate creosote oil. Three plants recommended paving oil similar to that quite generally used for wood block street paving. One recommended water-gas-tar; one carbolineum; one a mixture of half water-gas-tar and half zinc chloride solution; and one a mixture of half water-gas-tar and half coal-tar creosote. The last mentioned product was, however, recommended only for wet situations, this plant recommending creosote injected by the Rueping process for dry situations. The consensus of opinion was to use a distillate creosote, especially for dry situations, and a heavier paving oil for wet conditions.

In general, the plants were not very specific as to the absorption of preservative that they recommended for the two classes of blocks. The inference to be drawn, however, was that comparatively light absorptions (from 5 to 8 or 10 lbs. per cubic foot) would prove satisfactory for dry situations. Heavier absorptions, ranging from 8 to 16 lbs. per cubic foot, were recommended for alternately wet and dry or for wet situations. In general, the absorption to be given would appear to depend to a considerable extent upon the conditions met with in each individual problem, the more severe conditions especially as to the chance of the water coming in contact with the blocks, requiring heavier absorptions of oil. In the case of plants recommending paving oil and water-gas-tar, heavier absorptions were specified than when creosote was recommended.

*Abstract of paper read before the American Wood Preservers' Association.

Letters were written to a large number of users of wood block flooring, to obtain information on the character of the floors being laid and the results obtained. One hundred and sixty replies were received. About 75% of the replies describe floors laid in 1912 or later, while only three records were received of floors laid prior to 1909. This indicates the comparatively recent development of this type of flooring. For this reason, also, the time of service of these floors has been so short that not much information can be given upon durability.

The depth of block used varied from 2 to 6 ins., but 3-in. was used in 50% of the floors concerning which replies were received. Southern yellow pine was used in 72% of the cases, while 15% did not reply to the question, the remaining 13% being divided between eight other species of wood.

Concrete foundation was reported in 80% of the replies, the remainder being plank, dirt, tamped earth, etc., or not answering the question. Seventy-one per cent. reported the use of sand cushion, 12% cement grout cushion, and 3% bituminous cushions. Bituminous fillers were reported by 44%, and sand by 25%. Thirty-nine per cent. reported that expansion joints were used, while 41% did not use them, and 20% did not reply to the question.

Summing up, the general practice was to use 3-in. southern yellow pine blocks treated with 15 lbs. or more of creosote per cubic foot by the Bethell process. These were laid with a concrete foundation, sand cushion, bituminous filler, and the question of using expansion joints depended on the local conditions in each case.

Repairs have been reported in 32% of the records, while 62% reported no repairs. In most cases the repairs made were of a minor character, and as a rule, were caused by swelling or shrinking of the wood. In a few cases blocks were badly worn where heavy castings were thrown upon them.

Bleeding of the blocks was reported in 9% of the records, but was said to be objectionable in only 2.5% of the cases. Swelling was reported in 29% and shrinking in 27% of the records, (in some cases both swelling and shrinking were reported), and these troubles were the cause of most of the dissatisfaction reported. Swelling occurred when the blocks became accidentally wet, because of leaky roofs, bursting water pipes, near drinking fountains, and other accidental causes. Shrinking occurred in very warm or hot situations, and resulted in the blocks becoming loose and producing an uneven floor.

An interesting relation may be shown between the kind of filler used, and swelling and shrinking reported. Thirty-three per cent. of those using bituminous filler reported this trouble, compared with 55% of those using sand filler, 75% where cement grout was used, and 55% where no filler was used.

Eighty-nine per cent. replied that the blocks were satisfactory, while 5.6% did not reply to the question, and 5.6, or nine records, stated that the flooring was not satisfactory. Of the nine unsatisfactory floors, shrinkage of the blocks was responsible for dissatisfaction in three cases, swelling in two cases, in two cases the blocks wore out rapidly, poor foundation in one case and improper laying in one case.

In a large proportion of cases it was reported that wood block was easy on the feet of the workmen and that they like to work on it. Noiselessness, ease of repairs, low upkeep cost, good trucking surface, saving of breakage in tools and fragile metal parts dropped on the floor, warmth, and cleanliness were all reported as advantages of wood block flooring in 10 or more of the records. Durability was reported as an advantage in 77 cases, though it is doubtful if many of the floors had been in service sufficiently long to warrant a statement as to durability.

In 14 records swelling was given as a disadvantage and shrinking in 12 records. Roughness, reported in 11 records, was mostly caused by shrinkage. High cost was given as a disadvantage in 11 cases.

The results of this investigation indicate that treated wood block makes a desirable type of flooring for many purposes, and it is likely that its use for interior work will increase. Since its large use for these purposes is just beginning, one might expect that unforeseen trouble would develop. The records of 160 floors given in this report indicate, however, that serious trouble has developed in a very low percentage of cases.

Most of the trouble has come from shrinkage or expansion of the blocks. To prevent these troubles it is essential to study each case where blocks are to be laid, and to treat the blocks accordingly. For dry situations, the blocks should be well seasoned before treatment and laid in the floor while thoroughly dry. In wet or alternately wet and dry situations, dry blocks would give expansion trouble and, hence, the timber should be green or only semi-air-dried when laid. Even dry interiors are liable to be accidentally subjected to water, however; hence, it would seem desirable as a rule to use bituminous fillers instead of sand filler.

Sand cushions were probably a source of trouble in several cases. If there is any vibration, or if the sand is at all liable to shift, a bituminous or cement grout cushion is to be preferred. Sand cushions are also liable to cause uneven floors if the blocks shrink, and it seems likely that many cases of shrinking would not give serious trouble where bituminous filler and bituminous or cement grout cushions are used.

Bleeding caused very little trouble. In dry and very warm situations, where it is most likely to occur, it would be desirable to carefully consider the method of treating and handling the blocks in order to avoid objectionable bleeding.

In a few cases it seems likely that wood block should not be used. For example, it should not be used where butter or tobacco products are stored. In some foundries, where hot castings are thrown upon the floor, the blocks have burned through to the foundation. Wood blocks may be objectionable where the soiling or staining of certain classes of merchandise would lower the value, and in one case where used in a tennis court wood blocks were a failure and had to be removed.

Wood block was found to be very satisfactory in many cases where heavy castings are thrown about, where heavy trucks are moved, and is liked by workmen because it is warm and is easy on their feet.

The replies from the users of wood block flooring indicate quite strongly that when new wood block floors are to be laid, a careful investigation of all the conditions existing or likely to develop should be made by the manufacturer. The method of treatment and construction of the floor should then be adapted to the special conditions found.

Electrification of steam railroads in the United States last year brought the total of such equipment up to about 2,500 miles.

The British Columbia Electric Railway Company are proceeding with the completion of a large sub-station in Burnaby, B.C., the work on which has been suspended for the past two years

The Engineer's Library

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BOOK REVIEWS.

Hydraulics. By R. L. Daugherty, A.B., M.E., Assistant Professor of Hydraulics, Sibley College, Cornell University. Published by McGraw-Hill Book Co. (Inc.), New York. First edition. 204 pages, 243 illustrations and diagrams, 12 tables, 6 x 9 ins., cloth. Price, $2.50. (Reviewed by H. G. Acres, Hydraulic Engineer, Ontario Hydro-Electric Commission.)

This is the third hydraulic treatise so far published by Mr. Daugherty, the other two being entitled "Hydraulic Turbines," and "Centrifugal Pumps." After having published two text-books involving the application of rather advanced hydraulic theory, the author has possibly found that the elucidation of this theory to his classes could be more satisfactorily accomplished with the assistance of an elementary text-book of his own devising. Hence the volume under review which should therefore be considered as introductory to the two previous volumes, although as a matter of fact, the three volumes overlap to a considerable extent.

The volume is divided into sixteen chapters, nine of which are devoted to theoretical discussion and the derivation of general formulae. Chapters ten to sixteen deal with the simple theory of impulse wheels, reaction turbines and centrifugal pumps and their characteristics. This section also contains well-chosen descriptive matter, profusely illustrated, in connection with the installation and operation of the most modern hydraulic machinery and the layout of modern hydraulic developments.

In the first nine chapters there are three general subdivisions of the text. The first four chapters cover the theory of hydrostatics, chapter four being devoted to a concise but comprehensive discussion on the practical application of hydrostatic principles to the design of dams.

Chapters five to eight inclusive deal with water in motion, including the ordinary treatment of flow over weirs, flow through orifices, short tubes, pipes and in open channels. Of special interest is the derivation of the general equation for steady flow by the application of Bernoulli's theorem, and the subsequent discussion of its significance and limitations.

Chapter nine deals with the dynamic characteristics of water in motion, the argument leading up to the explanation and derivation of the general torque equations for turbines and pumps. This chapter also includes a brief discussion of water-hammer and surges in long pipes.

The remainder of the volume, with the exception of chapters thirteen, fourteen and sixteen, is largely descriptive matter. In the three chapters above mentioned, the theory of the impulse wheel, the reaction turbine and the centrifugal pump is covered suggestively, but as the treatment is intentionally academic, the general expressions derived are not directly applicable to practical design.

This little volume is a model of terse treatment, which is at the same time adequate by reason of the discriminating judgment with which fundamental principles have been seized upon and elucidated. On this account, while designedly a student's text-book, it is also an extremely useful reference book for any practicing engineer, whose work brings him in contact, more or less intermittently, with the simpler hydraulic problems.

Waterworks and Sewerage Systems of Canada. Compiled by Leo. G. Denis, B.Sc., Hydro-Electric Engineer, Commission of Conservation. Published by the Commission of Conservation of Canada. Contains 176 pages and 28 illustrations. (Reviewed by S. Harvey, A.M.Can.Soc.C.E., Sewer Department, City Hall, Toronto.)

In 1912 a report was published by the Commission of Conservation on the "Waterworks of Canada," being the principal physical data regarding waterworks systems in existence in the Dominion at that time. The great demand for that report proved its value and it was decided to compile another report which would revise that of 1912, and also embody a report on the sewerage systems of Canada.

This book is of a very useful character, setting forth in a condensed form the salient points connected with the numerous waterworks and sewerage systems of the Dominion.

Engineers have oftentimes occasion to refer to other towns and cities for statistics which may be readily gathered from this report.

As there are new systems and extensions to existing systems being constructed continually, this book will require to be revised every year in order to retain its value as a book of reference.

Irrigation Practice and Engineering, Vol. II., Conveyance of Water. By B. A. Etcheverry, Head of the Department of Irrigation, University of California. Published by McGraw-Hill Book Co. (Inc.), New York. First edition, 1915. 364 pages, 82 illustrations, 9 x 6¼ ins., cloth. Price, $3.50 net. (Reviewed by Lieut. T. W. J. Lynch.)

This volume is devoted to the design and construction of the conveying channels that bring water to the farms, including flumes, pipes, syphons and tunnels.

It opens with a chapter on the general features and investigations precedent to design, followed by a chapter dealing with the planning and location of the system.

The hydraulics of design of canals, flumes, pipes, etc., are next considered. As usual in American texts, Kutter's formula for the flow in open channels is given to the practical exclusion of all others, and as a consequence there is the usual presentation of another new diagram for the solution of this complicated and cumbersome equation.

The silt problem, losses from canals and the design of canal sections are next taken up. The seventh chapter is a very complete presentation of the subject of canal linings and prevention of losses. Numerous examples are cited by description and illustration, and the question of methods and costs is very fully dealt with. This is a subject which most text-books on irrigation seem to fight shy of or ignore and this chapter is a refreshing change. The material presented is drawn from a wide range of examples covering all conditions. Chapter 8 elaborates on tunnels, retaining walls, sections and bench flumes.

Chapter 9 deals with flumes and Chapter 10 with pipes and syphons. The latter, which is by far the longest chapter in the volume, is the only one in which design is treated from any other point of view than that of carrying capacity. In this chapter the design of pipes is handled from the hydrostatic point of view as well as the hydraulic.

To summarize, Volume II. contains abundance of valuable information for the young engineer engaged in irrigation practice when his professional experience should be augmented by some valuable treatise on irrigation.

Masonry Dam Design. By C. E. Morrison and O. L. Brodie. Published by Wiley & Sons, New York. Second edition, revised and enlarged, 1916. 276 pages. Price, $2.50 net. (Reviewed by G. R. G. Conway, Mem.Can.Soc.C.E.)

The authors of "Masonry Dam Design" are to be congratulated upon this second and enlarged edition of what, in its earlier form, as published in 1910, was a somewhat inadequate treatment of the subject. In this edition they have grouped in convenient form the latest investigations into the theory of masonry dams that have been discussed so fully during the last few years. In England, much careful investigation has been made in connection with this subject by such well-known authorities as Professor Unwin, Professor Karl Pearson, L. W. Atcherly, Sir John Ottley, Dr. A. W. Brightmore, E. P. Hill, and others, and probably the best record of their work is contained in the very valuable discussion published in Volume 172 of the proceedings of the Institution of Civil Engineers. On this continent very valuable studies have been made by the engineers of the New York Water Supply, and the subject was very fully discussed by leading American authorities in Volume 75 of the Transactions of the American Society of Civil Engineers. Read together with these two discussions, Messrs. Morrison and Brodie's book will prove of great interest to all students of masonry dam design.

The subject of uplift pressure and ice thrust is of great importance to engineers in this country; and, as the authors point out, for probably the first time it received due prominence in the design of the Wachussett dam in Massachusetts. Much space has therefore been given to the consideration of uplift and ice thrust, and in our opinion, in the authors' treatment of this branch of the subject lies the chief value of the book now before us. The book is essentially one for the student, but to the engineer looking for the latest summary of the various theories in connection with masonry dam design the book will be of interest.

Chapter VIII. is a discussion on recent considerations of the condition of stress in masonry dams, but the authors appear to have overlooked the work of Dr. Karl Pearson, who is largely responsible in England for the initiation of the experimental work done by later investigators, particularly those who have been utilizing models of dams composed of jelly and other plastic substances for experimental purposes. The practical engineer in reading this book might ask what value it has for him. He might turn to the very interesting appendix which contains profiles of a large number of notable dams, and point out that many of these dams were built years ago, and are not essentially different in profile from recent designs, and yet are to-day standing among the finest structures of their class—such, for example, as the Furens and Chartrain dams in France, the Villar dam in Spain, the Periyar dam in India, and many others which have caused no anxiety to their designers, while he might point out that the known failures have all been due to faulty foundations, and no matter how theoretically correct the design may be, the real problem of masonry design lies in the careful selection of site, the construction methods adopted to prevent the permeability of the structure, and the proper construction of cut-off trenches and outlet drains to prevent uplift pressures.

We believe that although the real problems of masonry design can be solved only by mature experience and judgment and the special consideration of each individual case, the authors' book is of real value to the practical engineer engaged in dam design, and is a welcome addition to the all too few books upon the subject.

In Appendix No. 3, which gives the cross-sections of many notable dams, we miss the profiles of several famous English examples, *e.g.*, Pen-y-Gareg and Craig Goch dams of the Birmingham Water Supply, and also those constructed in recent years by the Derwent Valley Water Board, all of which are among the finest examples of high masonry dams yet constructed.

A System of Physical Chemistry. Two volumes.. By William C. McC. Lewis, M.A., D.Sc. Published by Longmans, Green & Co., New York and London. Canadian selling agents, Renouf Publishing Co., Montreal. 523 pages, illustrated, 5 x 7½ ins., cloth. Price, $5 for set of two volumes. (Reviewed by J. W. Scott, Health Department, City Hall, Toronto.)

This book is intended for use as a general text book of physical chemistry for those who have a grounding in the subject.

It is not an elementary physical chemistry, the author aiming to make the book fairly comprehensive by including accounts of recent investigations, such, for example, as the structure of the atom, the theory of concentrated solutions, capillary chemistry, Nernst's theorem of heat, and so on. Besides these recently examined problems, the fundamental principles and their applications have been incorporated here. At the same time, the author suggests that the reader becomes fully familiarized with the broad outlines of the subject, which may be found in more elementary works.

Volume I. contains 510 pages divided into 10 chapters, and deals with or may be entitled the "Kinetic Theory." Volume II. contains 542 pages divided into 14 chapters and may be entitled "Thermodynamics and Statistical Mechanics."

This book covers the ground of advanced physical chemistry to perfection, but as a book for students the use of it is not to be recommended.

Maintenance of Way and Structures. By William C. Willard, C.E., M.S., Assistant Professor of Railway Engineering, McGill University. Published by the McGraw-Hill Book Co., New York. First edition, 1915. 450 pages, 225 illustrations, 6 x 9 ins., cloth. Price, $4. (Reviewed by J. R. W. Ambrose, M.Can.Soc.C.E., M.A.R.E.A.)

Of all the volumes published on engineering, very few have been devoted to railroad engineering as a whole. This edition has long been wanted, particularly as a text in universities where there has been a maximum of theory and a minimum of practical information.

The chapters, no doubt, are modelled after the Committees of the American Railway Engineering Association, the greatest of its kind in existence, which controls the railway engineering practice of this continent at least.

The chapter on Rules and Organization is excellent information for the student, but of no practical value to the railroad man, as each company has its own characteristics and the standardization of all would be impossible.

The impression given of track labor is wrong. This class of labor is becoming more important each year, and railway companies are beginning to recognize the possible economy and efficiency through this department.

The chapters on Roadway, Ballast, Ties, Wood Preservation, Rails, etc., are very good and profusely illustrated.

The article on rail anchors is descriptive, but later anchors, such as the "McCooe," might be added, which overcome the difficulties mentioned.

The chapter on Stresses in Track is excellent. This is a new subject and valuable to the engineer as well as the student.

The chapter on Bridges does not go into the design, but the illustrations are valuable to the practical man and particularly so to the student. The statement that ballast floor bridges are not generally waterproofed is incorrect. The author probably meant that special materials are not always used, but some method of waterproofing is always intended.

The remaining chapters give the recommended practice in a concise way, making a convenient reference for the engineer and an excellent text for the student.

The directions for railway drafting are exceptionally good.

As a railway engineering text book, the writer has not seen its equal. The illustrations are clear, instructive and numerous.

Engineering Office Systems and Methods. By John P. Davies, M.E. Published by McGraw-Hill Book Co., Inc., New York. First edition, 1915. 544 pages, 244 diagrams, forms and illustrations, 6 x 9½ ins., cloth. Price, $5.00 net. (Reviewed by H. G. Acres, hydraulic engineer, Ontario Hydro-Electric Power Commission, Toronto.)

The sub-title of this volume indicates its scope more effectively than the general title—"Schedules and instructions for the collection of preliminary data for engineering projects; sampling, inspecting and testing engineering materials; conducting domestic and export shipping operations, etc."

The text is divided into thirteen chapters, ten of which are devoted to engineering subjects. Chapters 5, 8 and 9, entitled respectively, "Purchasing—Office Methods and Forms," "Domestic Shipping," and "Export Shipping," have a much more general scope, as their titles indicate. Chapter 9 contains a well-handled description of procedure and routine formalities in connection with export shipping which could be most opportunely studied by many Canadian manufacturers who plan to invade foreign markets at the close of the war.

Chapters 10 and 11 are devoted to "Progress Charts, Scheduling Systems" and "Indexing and Filing Systems." While these subjects are treated from an engineering viewpoint, an intelligent reader could study these two chapters with profit and adapt the principles outlined to any class of heavy manufacturing. The description of the Dewey decimal system and the discussion of its manifold applications is particularly interesting.

The remaining chapters are more or less directly related to engineering office system and methods or "reminders," and the data required for (*a*) preparing specifications, (*b*) obtaining manufacturers' designs and quotations, (*c*) preparing engineering designs, (*d*) reporting on engineering projects, etc. Chapter 6 deals with cost keeping and estimating and Chapter 7 with sampling, inspection and testing of engineering material. With the exception of the chapter on cost keeping and estimating, these remaining chapters are of doubtful value. The information is not given in sufficient detail to be safely used by an inexperienced engineer, while on the other hand, it is of such a fundamental nature that it must obviously be part of the stock in trade of any competent engineer or inspector. The volume as a whole, however, is a very useful work of reference as related to heavy manufacturing, and should find a market not only among engineers, shop superintendents, etc., but among executives and officers having to do with the purely commercial phases of manufacturing.

Mechanical Engineers' Handbook. Lionel S. Marks, Editor-in-Chief. Published by McGraw-Hill Book Co., Inc., New York. First edition, 1916. 1,836 pages, 4½ x 7¼ ins. About 1,000 illustrations and diagrams. Flexible leather. Price, $5 net.

This handbook brings into the mechanical engineering field the principle of specialization which was introduced into the civil engineering field by the American Civil Engineers' Pocket Book. Prof. Marks, who is professor of mechanical engineering at the Massachusetts Institute of Technology, is the chief editor, but each of the fifteen main sections of the book was written by a specialist.

The book is based upon the German, "Hütte." The German book includes civil and electrical engineering, however, and those portions are not included, arrangements having been made with the Germans for the use of only such portions of their handbook as were required. The greater part of the book must be regarded as new, although the subjects of friction and hydraulic turbines follow "Hütte" closely, while a few of the more theoretical topics, such as heat and mechanics of materials, follow "Hütte" in a general way, with important departures, however.

The specialists who contributed to the book have furnished new data on machine tools and machine shop practice, hoisting and conveying, pipe and pipe fittings, heat, lubricants, paints, weights and measures, refrigeration, fractory accounts and costs, industrial buildings, air conditioning, illumination, fans, hydraulic turbines, air compressors, pumps, measuring instruments, gas engines,

steam turbines, fire protection, aeronautics, automobiles, and a large number of other mechanical subjects.

The book is a very useful and welcome addition to mechanical engineering literature.

PUBLICATIONS RECEIVED.

Department of Mines.—Summary report for 1915 of the Geological Survey, Department of Mines, Ottawa. Price, 15 cents.

Canal Statistics.—1915 report of the Department of Railways and Canals, Ottawa, containing 103 pages. Price, 10 cents.

Financial Report, 1915, of the J. G. White Companies, New York, giving annual returns and balance sheet of these companies.

Ore Deposits of the Beaverdell Map Area.—By Leopold Reinecke. Memoir 79, No. 65, Geological Series, Department of Mines, Ottawa.

Report of Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, City of New York, for the year 1914. 235 pages, 42 tables.

Geology and Ore Deposits of Rossland, B.C.—Memoir 77, No. 64, Geological Series, Department of Mines, Ottawa. By Charles Wales Drysdale.

Geology of Field Map—Area, British Columbia and Alberta.—Memoir 55, No. 46, Geological Series, Department of Mines, Ottawa. By John A. Allen.

Gas Plant Construction.—Published by the Stone and Webster Engineering Corp., Boston, Mass. Contains 24 illustrations of various gas and power plants.

Sewage Disposal.—Tenth and eleventh semi-annual reports, 1915, of the Sewage Disposal Commission of the city of Fitchburg, Mass. Published by the Fitchburg H. M. Downs Printing Co.

Highway Improvement in Ontario.—Annual Report, Department of Highways, Toronto, 1915, by W. A. McLean, commissioner of highways. 223 pages, well illustrated by charts and photographs.

The Strength and Stiffness of Steel Under Biaxial Loading.—Bulletin No. 85, Engineering Experiment Station, University of Illinois, Urbana, Ill. By Albert J. Becker. 65 pages, illustrated. Price, 35 cents.

Experiments on the Economical Use of Irrigation Water in Idaho.—Bulletin No. 339, U.S. Department of Agriculture, Washington, D.C. By Don H. Bark, irrigation engineer, Division of Irrigation Investigations.

Tests of Reinforced Concrete Flat Slab Structures.—Bulletin No. 84, Engineering Experiment Station, University of Illinois, Urbana, Ill. By Arthur N. Talbot and Willis A. Slater. 128 pages, 85 illustrations. Price, 65c.

Good Roads Year Book, 1916.—The fifth annual edition of this useful publication has been issued. It contains a great deal of information regarding road improvement, historical notes, road materials and road machinery. W. A. McLean, Deputy Minister of Highways of Ontario, has an article in it dealing with highway improvements in Canada, and the Hon. B. Michaud, Deputy Minister of Highways of the Province of Quebec, contributes an article dealing with the roadway organization of that province. It contains 440 6 x 9-in. pages.

Annual Report on the Mineral Production of Canada.—Issued by the Department of Mines, compiled by John McLeish, B.A., chief of the division of mineral resources and statistics. This report contains 366 6 x 9-in. pages. It is divided into three sections: First, metallic ores; second, non-metallic production; third, structural materials and clay products. A great many comparative statements are presented showing the production of each important product during the past two years, the production which each contributes to the total production and the increase or decrease, as the case may be, of the production in 1914 as compared with that of 1913.

CATALOGUES RECEIVED.

Steel.—1916 stock list of the steel department of Factory Products, Limited, 220 King Street W., Toronto.

Protecting the Water Supply of Greater New York.—An illustrated booklet issued by the Wallace & Tiernan Co., Inc., New York.

Microscopes.—A 129-page, illustrated booklet issued by the Bausch & Lomb Optical Co., Rochester, N.Y., describing their microscopes and accessories.

Small Motors.—Folder No. 25 issued by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., describing, with illustrations, Westinghouse motors for washing-machine service.

Trill Indicators.—A 56-page, illustrated booklet issued by the Trill Indicator Co., Corry, Pa., describing the latest types of engine indicators and accessories, with information on taking and reading of indicator cards.

William Bryce, Lothian Street, Edinburgh.—Catalogue of chemical and technical books comprising works in agriculture, chemistry, metallurgy, etc. Catalogue is very well classified and contains 56 5½ x 8½-inch pages.

Milburn Oxy-Acetylene Welding and Cutting Apparatus.—A 6-page, illustrated folder issued by the Alexander Milburn Co., Baltimore, Md., describing their welding torch, regulators, cutting torch, welding generator and portable plant.

Manganese Chains.—Bulletin No. 171, issued by the Jeffrey Manufacturing Co. Contains full details and prices of "manganese" chains. Copy of the bulletin can be secured by addressing the Montreal office of the company, Power Building, Montreal.

Small Electrically Driven Centrifugal Pumps.—Bulletin No. S-1000, issued by Yeomans Brothers Co., Chicago, describing their centrifugal pumps for house supply and general service in office buildings, apartment buildings, power plants, etc. 11 pages, illustrated.

Yeomans Duplex Electric Centrifugal Sewage Ejectors.—Bulletin No. E-2000 of Yeomans Brothers Co., 231 Institute Place, Chicago, describing their sewage ejectors for automatically raising sewage and drainage in basements below street sewer level, municipal sewage systems, etc. 11 pages, illustrated.

Oil Filters.—Bulletin No. 5, recently issued by the Richardson-Phenix Co., Milwaukee, Wis., describing a complete line of filters for purifying lubricating oil, having capacities of from 25 gallons per day to 50,000 gallons per hour. The catalogue is well illustrated and contains prices on the various size filters.

Wagon and Truck Loaders.—Bulletin No. 177 of the Jeffrey Manufacturing Co., Columbus, Ohio, featuring their self-propelling wagon and truck loaders for handling crushed stone, sand, gravel, etc. Contains 23 pages and illustrations of many interesting installations, specifications, prices and complete details of their different types of loaders.

Editorial

INDUSTRIAL RESEARCH.

It seems to be a pretty well fixed belief that knowledge should be pursued for its own sake, and that the quest for truth should be unhampered by anything that even has the semblance of utilitarianism about it.

Since the outbreak of war much has been written concerning the necessity for greater activity in the realm of industrial research in Canada. This is a subject which should not be left altogether to universities and scientific bodies. Manufacturers, if they are to maintain their superiority, must recognize that they, too, have responsibilities in connection with the development of industrial research in this country.

Certain large individual industries, as well as groups of industries, have spent large sums of money for research work. Monies have been and are now being spent in this country for this kind of work, but it is very spasmodic. It is a question as to whether we are as a people, and especially as manufacturers, attaching sufficient importance to this matter, and whether we are dealing with it in a corporate and national spirit.

While application and genius are necessary if research work is to be carried to a successful conclusion, money also is called for.

Many men are conducting research work, but are very much handicapped by the lack of apparatus which is absolutely necessary if the best work is to be done. Would it not be possible to gather up these loose ends of disconnected effort by greater co-operation between scientific and industrial groups and seek to approach the problem in a more intelligent, broader and really national sense?

THE ENGINEERS' LIBRARY.

For several years *The Canadian Engineer* has made a practice of publishing in the last issue of each month a department known as the Engineers' Library. In this department are to be found reviews of the new engineering books of the month, these reviews being written by engineers who have made a special study of the subjects with which the books deal. Under the heading of "Publications Received" there is given a review of reports issued by various public bodies which are more or less related to the engineering profession, while under the heading of "Catalogues Received" appear brief summaries of the trade literature of the month.

Every engineer, no matter in what particular branch of the profession he is interested, must feel, in view of the rapidity with which engineering practice changes and the speed with which one development follows another, the need of keeping himself posted, and has a more or less complete selection of text and reference books of his own.

The Engineers' Library as found in *The Canadian Engineer* can be made of great service to the man who recognizes the importance of having beside him at least a few standard general engineering books as well as others which deal more specifically with the phase of engineering with which he is especially interested for reference purposes. Such a collection of books will be found a tool by no means the least useful.

Reports of public officials, publications of engineering societies contain information of value to all engineers, while trade literature, though primarily advertising, very frequently contain data that will be found serviceable to the engineer in his work.

Two things usually limit the extent to which an engineer will build up a library: the demands of his everyday work, and the time and facilities at his disposal for collecting and filing information.

It is in order to render our subscribers the greatest possible assistance in selecting such material as they think should rightly find a place in their collection, that this department was established and is being maintained.

ECONOMIC VALUE OF THE GOOD ROADS MOVEMENT.

The development of the good roads movement will unquestionably help to solve many economic and social problems with which we are confronted to-day. Slowly, but none the less surely, people are beginning to realize the great importance of permanent road construction and to recognize the real significance of the movement.

While a great deal has been done in highway engineering in Canada, there is yet a great deal to be accomplished.

Those who cry "back to the land" will never get very far unless simultaneously with it they lend their practical support to the efforts which various bodies are making, looking to a betterment in the design, construction and maintenance of highways throughout the country.

Many farms that to-day are deserted would never have been so treated had the good roads idea come into service touch with them, and thus made it possible for the tenants to get and keep in more intimate contact with the communities immediately beyond their own borders.

The public highway is, after all, more generally used than any other means of communication, and is free and open to all classes of the community. It is well known that where a community passes from a condition in which poor roads are a rule to one in which good roads dominate, land values advance. The redistribution of a considerable portion of the population in such a way as to remove congestion in the cities and add them to the dwellers in rural communities has been given a great stimulus and will continue to be greatly stimulated by the good roads movement.

There are many districts all over Canada, rich in agricultural products but poor in roads. Such a community is under an enormous handicap. The incoming shipments greatly exceed the outgoing, whereas with improved road condition, these same communities could not only be self-supporting, but could ship products to other markets.

In very many quarters, at least, the real significance of highway improvement is not appreciated and objections

to the development of the movement are made largely because of a lack of understanding and a real appreciation of its value from a social and economic point of view.

PERSONAL.

W. A. MAHONEY has been appointed water commissioner at Guelph, Ont.

CHARLES L. MARBLE has been appointed manager of the Wayne Oil Tank & Pump Co., of Woodstock, Ont.

PATRICK LYONS has been appointed general superintendent of the waterworks department of Quebec City.

L. T. WALLS, formerly of the Steel Co. of Canada, has been appointed general sales manager of the Manitoba Rolling Mill Co., Limited.

P. Z. CAVERHILL, forester for the Province of New Brunswick, has begun a survey and inventory of the provincial Crown lands.

D. O. LESPERANCE has been appointed chairman of the Quebec Harbor Board, to succeed Sir William Price, who recently resigned.

ALEX. WILSON, distribution engineer of the Montreal Light, Heat and Power Company, has been appointed Lieutenant in the 244th Battalion now being raised.

J. D. McMILLAN has been appointed superintendent of the Belleville Division (Districts 5, 6, 7, 8, 9 and 10), Grand Trunk Railway System, with headquarters at Belleville, Ont., to succeed H. F. Coyle, deceased.

J. R. BOOTH, the veteran lumberman, of Ottawa and Hull, recently celebrated his ninetieth birthday. Despite his age, Mr. Booth continues to take a very active interest in all of his companies' activities, and even helps around the mills.

E. L. COUSINS, chief engineer of the Toronto Harbor Commission, has just been appointed general manager, a reorganization of the office staff having been made necessary by the enlistment of Major Alex. Lewis, who had acted as secretary since the inception of the commission.

JAMES M. NELSON, who recently resigned as superintendent of the open-hearth department of the Carnegie Steel Co. works at Youngstown, Ohio, has been appointed superintendent of the open-hearth and duplex steel departments of the Algoma Steel Corporation at Sault Ste. Marie, Ont.

E. R. GRAY, assistant city engineer of Hamilton, Ont., has been recommended by the Board of Control for the position of chief engineer, to succeed A. F. Macallum, and A. P. KAPPELE, the present secretary of the works department, has been recommended for the position of manager of that department.

Capt. ALBERT PETER MILLER, Glen Miller, Ont., 21st Battalion 2nd Division, A.M.Can.Soc.C.E., graduate Royal Military College, Kingston, has been awarded the Military Cross for bravery at the battle of St. Eloi. Capt. Miller was formerly resident engineer of the National Transcontinental Railway, Vermilion Bay, Ontario.

J. W. B. BLACKMAN, city engineer of New Westminster, B.C., has been awarded first prize by the Institute of Municipal and County Engineers for an article on the construction of the 25-inch water main which supplies water to New Westminster, and of the 13-inch submerged main leading to Richmond.

Col. G. S. MAUNSELL, Director-General, will shortly leave for overseas to take an important position in the Canadian Engineers at the front. It is understood that Lieut.-Col. A. P. DEROCHE will be Acting Director-General during the absence of Col. Maunsell. Lieut.-Col. Deroche has been in charge of the construction work of the engineering service since the war broke out.

Capt. FRANK P. ADAMS, of the 186th overseas battalion, who for several years has been city engineer of Chatham, Ont., was recently honored, on the occasion of his departure for the training camp at London, by the city councils of 1913-14-15-16, under whose direction he served. He was presented with a purse of gold, and members of the respective councils made brief addresses complimenting him upon the efficiency and courtesy which he had always shown and the very satisfactory service he had rendered the city.

OBITUARY.

Lieut.-Col. F. A. CREIGHTON, Mem.Can.Soc.C.E., has, according to a private message received in Winnipeg, died of wounds. He was City Engineer of Prince Albert before the war.

Company Sergeant-Major ARMSTRONG has been killed in the recent fighting. He was a graduate in science of McGill University. Prior to joining the forces he was on the engineering staff of the city of Montreal.

Col. HERBERT J. BOWMAN, M.Can.Soc.C.E., died June 19th at the Berlin, Ont., Hospital. Col. Bowman was a well-known consulting engineer, having handled many important works during the past thirty years. He was born in Berlin, Ont., June 18th, 1865. He graduated from S.P.S., Toronto, in 1885 and became assistant to P. S. Gibson, the engineer of York Township. In 1887 he qualified as provincial land surveyor for Ontario, and became transit man for the Berlin and Pacific Junction Railway. In 1888 he was engineer for Berlin on waterworks construction, and from the completion of the work to 1892 was superintendent of waterworks. He was then appointed town engineer, and for the following three years was engaged in the design and construction of a sewerage system under the direction of consulting engineers C. H. Rust and Willis Chipman. In September, 1896, he succeeded his father as clerk and treasurer of Waterloo County, and this position he held until death. About 1903 he carried out special survey work in Saskatchewan for the Dominion Government, and in 1908 he joined with A. W. Connor in the consulting engineering firm of Bowman & Connor. Among the work which Col. Bowman did as a member of this firm were waterworks systems for Hespeler, Preston, Fergus, Elmira, Chesley, Gravenhurst, Penetang, and other Ontario towns; the reconstruction of the Berlin waterworks, including the erection of one of the largest concrete water towers in the world; and bridges for Wellington, Waterloo, and other Ontario counties. While attending college, Col. Bowman became a member of the Queen's Own Rifles, and when he returned to Berlin he joined the 29th Regiment and was its commanding officer for some years. Upon the outbreak of the present war he organized the 108th Regiment in Berlin, and was its commanding officer at the time of death. He had been a member of the Berlin Water Commission for nearly twenty years, and was ex-president of the Waterloo County Canadian Club. He is survived by his wife, two daughters and two sons.